MATERIALS BUREAU

Materials Method 5.16
SUPERPAVE
Hot Mix Asphalt
Mixture Design and
Mixture Verification Procedures

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

Superpave Item Number Description

18 403 . XX Y Z Q R

18 — **Specification Prepared by the Materials Bureau**

403 — **Reference to Standard Specifications Sub-Section**

XX — **Reference to Mixture Nominal Maximum Aggregate Size**

09 = 9.5 mm, Top Course
12 = 12.5 mm, Top Course
19 = 19.0 mm, Binder Course
25 = 25.0 mm, Binder Course
37 = 37.5 mm, Base Course
21 = Truing and Leveling Course

Y — **Reference to Compaction Requirements**

5 = Daily Coring with Payment Adjustments (HD)
6 = Nuclear Gauge Monitoring with Core Verification (RA)
7 = Nuclear Gauge Monitoring only
8 = Miscellaneous Items (Truing and Leveling, Optional Flexible Shoulders, Pavement Shoulder Course)

Z — **Reference to the Coarse Aggregate Friction Requirement**

1 = F1 - Downstate, High Volume
2 = F2 - Upstate, High Volume
3 = F3 - Low Volume
9 = F9 - No Friction Requirement

Q — **Reference to Quality Adjustment Items**

0 = Specified HMA Item (Core Item)
1 = Plant Production Quality Adjustment
2 = Pavement Density Quality Adjustment
3 = Longitudinal Joint Density Quality Adjustment
4 = Pavement Smoothness Quality Adjustment

R — **Specification Revision Number**

SUBJECT: **SUPERPAVE HOT MIX ASPHALT MIXTURE DESIGN AND MIXTURE VERIFICATION PROCEDURES**

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Supersedes: MM 5.16 M (Interim)
Dated: February 28, 1997

PREFACE

Materials Method 5.16 M describes NYSDOT's requirements and policies for the development of Superpave Hot Mix Asphalt (SHMA) mixture designs, including the responsibilities of the Producer and the Department. This Method also gives the specific testing details and evaluation procedures, to be followed in the SHMA mixture design process. Conformance with Materials Method 5.16 M assures uniform testing and evaluation of paving mixtures through volumetric analysis of laboratory and plant prepared specimens.

The purpose of the Superpave Hot Mix Asphalt mixture design system is to design SHMA mixtures that achieve the fundamental volumetric properties needed to result in maximum pavement performance. It is extremely important that the plant quality control procedures outlined in the Producer's Quality Control Plan are followed to ensure uniform production.

Department personnel may suggest to a Producer methods for improving a mixture design, with the understanding that the suggestions do not bind NYSDOT to accepting material outside of specifications.

Note: This Materials Method may require the use of hazardous materials and safety sensitive procedures. This Method does not address any of the safety problems associated with its use. It is the responsibility of the user of this Method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

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I. SCOPE

This Materials Method describes the responsibilities and procedures for the development and review of Superpave (an acronym for SUperior PERforming asphalt PAVEments) hot mix asphalt (SHMA) mixture designs. This Method outlines a complete procedure for the uniform design of mixtures having a nominal maximum aggregate size of 9.5 mm, 12.5 mm, 19.0 mm, 25.0 mm, or 37.5 mm.

II. GENERAL

The Superpave mixture design system and Performance Graded Binder (PGB) specifications were developed through research performed during the Strategic Highway Research Program (SHRP). Superpave addresses the three principal distresses that plague HMA pavement: rutting, fatigue cracking, and low temperature cracking. Superpave is performance based; both the PGB specification and mixture design system identify the performance properties directly related to pavement durability. The requirements for each property are tailored to accommodate for the diverse, but specific, climate and traffic conditions that pavements are exposed to at projects sites across the State.

The objective of the Superpave mix design system is to define an economical blend of PGB and aggregate yielding a paving mixture having sufficient air voids, voids in the mineral aggregate (VMA) and voids filled with binder (VFB) that will perform satisfactorily over the pavement's service life. The Superpave design method provides an objective measure of the benefits or penalties associated with the use of materials of varying quality.

The Superpave mixture design procedure is used to establish proper proportions of aggregates, reclaimed asphalt pavement (when applicable), and PGB to meet the required mixture volumetric properties, given the specific traffic and weather conditions of the project location. Reclaimed asphalt pavement (RAP) may be used in the design and production of any SHMA mixture.

The Producer is responsible for preparing the SHMA design; NYSDOT is responsible for checking the submitted mixture design for completeness and accuracy. The Regional Director or his representative has final acceptance authority.

A complete SHMA mixture design is required for each aggregate source combination, each aggregate gradation, each RAP stockpile, and each plant using the same aggregate at a site having multiple plants. The Regional Director or his representative may waive the requirement for separate mixture designs for multiple plants using the same materials, if the aggregate gradation meets the JMF and the Producer can prove, by abbreviated volumetric tests on material produced in each plant, that the mixture's volumetric properties meet all requirements.

III. INFORMATION SOURCES

The following is a list of the various sources of information that must be consulted, in addition to this Method, to prepare an SHMA Mixture Design.

1. NYSDOT Standard Specifications - including all addenda and the project proposal.
2. NYSDOT Approved List - Sources of Fine and Coarse Aggregates.
3. NYSDOT Materials Method 5 M - Plant Inspector's Manual for Bituminous Concrete Mix Production.
4. NYSDOT Materials Procedure 94-4 -Testing Frequencies using Random Sampling at a Hot Mix Asphalt (HMA) Plant.
5. AASHTO M 231 - Specification for Weighing Devices Used in the Testing of Materials.
6. AASHTO MP 1- Specification for Performance Graded Asphalt Binder.
7. AASHTO MP 2 - Specification for Superpave Volumetric Mix Design.
8. AASHTO PP 2 - Practice for Short and Long Term Aging of Hot Mix Asphalt.
9. AASHTO PP 19 - Practice for Volumetric Analysis of Compacted Hot Mix Asphalt
10. AASHTO PP 28 - Practice for Superpave Volumetric Design for Hot Mix Asphalt.
11. AASHTO T 11 - Test Method for Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing.
12. AASHTO T 27 - Test Method for Sieve Analysis of Fine and Coarse Aggregates.
13. AASHTO T 84 - Test Method for Specific Gravity and Absorption of Fine Aggregates.
14. AASHTO T 85 - Test Method for Specific Gravity and Absorption of Coarse Aggregates.
15. AASHTO T 100 - Test Method for Specific Gravity of Soils.
16. AASHTO T 166 - Test Method for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens.
17. AASHTO T 176 - Test Method for Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
18. AASHTO T 209 - Test Method for Maximum Specific Gravity of Bituminous Paving Mixtures.
19. AASHTO T 228 - Test Method for Specific Gravity of Semi-Solid Bituminous Materials.
20. AASHTO T 245 - Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus. (HMA).
21. AASHTO T 304 - Test Method for Uncompacted Void Content of Fine Aggregate (2).
22. AASHTO TP 4 - Method Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the SHRP Gyratory Compactor.
23. ASTM D4402 - Viscosity Determinations of Unfilled Asphalts Using the Brookfield Thermosel Apparatus.
24. ASTM D4791 - Flat Particles, Elongated Particles or Flat-and-Elongated Particles in Coarse Aggregate.
25. ASTM D4867 - Effect of Moisture on Asphalt Concrete Paving Mixtures.
26. ASTM D5821 - Determining the Percentage of Fractured Particles in Coarse Aggregate.
27. Asphalt Institute Technical Bulletin - Laboratory Mixing and Compaction Temperatures.

All NYSDOT listed references are available from the New York State Department of Transportation. Contact the Regional Materials Engineer for further information.

All AASHTO listed references are available from:

American Association of State Highway and Transportation Officials
444 North Capitol Street, NW
Suite 225
Washington, D.C. 20001
Phone: (202) 624-5800

All ASTM listed references are available from:

American Society for Testing and Materials
1916 Race Street
Philadelphia, Pennsylvania 19103-1187
Phone: (215) 299-5400

All Asphalt Institute listed references are available from:

Asphalt Institute
2696 Research park Drive, P.O. Box 14502
Lexington, KY 40512-4052
Phone: (978) 681-9210

IV. DETAILS OF RESPONSIBILITY

A. PRODUCER

The Producer is responsible for furnishing a complete SHMA mixture design to the Department, according to this Method. The mixture's volumetric properties must meet all volumetric criteria.

The Producer's responsibilities include:

1. Analysis of Plant Aggregate Gradation

Obtain gradation data, and develop a producible target gradation, meeting all control point and restricted zone criteria.

2. Establishing and Maintaining RAP Stockpiles

For the design and production of SHMA mixtures, RAP is a stockpile aggregate material. Include provisions for maintaining RAP stockpiles in the production facility's Quality Control Plan. All aggregate in a RAP stockpile must meet all requirements of Section V-A. 1. of this Method, "Aggregate Selection / Requirements." The RAP's binder

component must be asphalt binder and free of asbestos and significant contents of solvents, tars or other contaminating substances.

Material may be added to a RAP stockpile, if the aggregate in the material being added to the stockpile meets all of the requirements referenced above. As with other aggregates RAP should be stockpiled by size. Material that differs in gradation from an existing stockpile should be processed to match the gradation of the existing stockpile before being added, or should be used to form a new stockpile.

Before designing recycled SHMA mixtures, establish at least one RAP stockpile. Use this stockpile for the design of Superpave recycled HMA mixtures and the production of all Superpave recycled HMA based on those designs. More than one mixture design may be developed for each stockpile.

3. Obtaining Aggregate and RAP Samples

Obtain representative aggregate and RAP samples according to Materials Method 5.0 M. Obtain a sufficient quantity of aggregate, to perform all testing detailed in this Method. A total combined aggregate and RAP mass of 130 kg should be sufficient. RAP samples must be processed to remove all material larger than the scalping screen which will be used during production and dried to a constant weight before being used. Submit a sufficient sample of aggregate and RAP to NYSDOT for mixture design verification.

4. Job Mix Formula (JMF) Development

Develop a JMF through a four-step process consisting of: selecting appropriate materials, developing a design aggregate structure, determining a design PGB content, and evaluating the resultant mixture's moisture susceptibility. If moisture susceptibility testing is required, it will be noted in the contract documents. The SHMA mixture must meet all aggregate quality, mechanical, and volumetric property requirements. Develop all JMFs according to this Materials Method.

5. Data Documentation

Document the resultant test data on NYSDOT forms or NYSDOT approved computer-generated forms. The Producer must fill out and sign all forms. The required forms are:

BR 253-257	Superpave Job Mix Formula *(specific form will vary with nominal maximum aggregate)*
BR 266-270	Superpave Design Aggregate Structure Trial Blend Gradation Plot *(specific form will vary with nominal maximum aggregate)*
BR 276	Superpave Design Aggregate Structure Trial Blend Compacted Specimen Volumetric Property Summary
BR 277	Superpave Design Aggregate Structure Trial Blend Compacted Specimen Volumetric Property Summary for Recycled Mixtures

BR 293	Superpave Design PGB Content Compacted Specimen Volumetric Property Summary
BR 294	Superpave Design PGB Content Compacted Specimen Volumetric Property Summary for Recycled Mixtures
BR 295	Superpave Volumetric Property Curves
BR 319	Superpave Design PGB Content Compacted Specimen Density Worksheet
BR 320	Superpave Performance Graded Binder Temperature Viscosity Data
BR 326	Superpave Average Washed Gradation Summary
BR 327	Superpave Batch Masses for Mixture Verification
BR 332	Superpave Design PGB Content Mixture Maximum Specific Gravity Summary - AASHTO T209

NOTE: Two BR 326 forms are required for batch plant facilities: one for stockpiles and one for hot bins.

NOTE: Two BR 319 forms and two BR 332 forms are required for all mixture designs: one of each for trial blends and one of each for design binder content determination.

6. SHMA Design Submission

Submit the completed SHMA mixture design to the Regional Materials Engineer. Include in the mixture design submission:

a. The above listed forms.

b. Sufficient PGB and aggregate samples as outlined in this Materials Method.

7. Production Notification

After the SHMA mixture design is assigned verification status, notify the Regional Materials Engineer 24 hours before initial production. If this notice is not given, mixture verification will not begin, and any material shipped without the appropriate notice will not be accepted.

8. Production Monitoring - Quality Control

Monitor all volumetric properties and aggregate gradations during production according to §402 - Quality Control Asphalt Concrete - General.

B. NYSDOT

This section outlines the review procedure of a submitted SHMA mixture design, for completeness and accuracy, performed by the Regional Materials Engineer.

1. SHMA Design Review

The Regional Materials Engineer will review the JMF and associated information for accuracy and completeness according to Section IX of this Method, "Verification." Based on this review the Regional Materials Engineer do one of the following.

a. Assign Verification Status to the design;

b. Reject the design for being incomplete;

c. Reject the design for not meeting the mixture volumetric criteria or the aggregate consensus property requirements;

d. Determine that the design does not meet criteria listed in Section IX of this Method, "Verification," and conduct a laboratory verification. The purpose of laboratory verification is to check the laboratory techniques used to complete the submitted design. After completing the laboratory verification (if required) the Regional Materials Engineer will either assign Verification Status to the design or reject it for not meeting the specified mixture volumetric criteria.

2. Production Monitoring - Quality Assurance

For each day of Verification Status production, the Department will determine the daily production Quality Adjustment Factor (QAF) according to §402 - Quality Control Asphalt Concrete - General. At the successful conclusion of mixture verification production, the Regional Materials Engineer will assign Production Status to the mixture design. During Production Status production the Department will determine the daily production QAF according to §402 -Quality Control Asphalt Concrete - General.

V. DESIGN PROCEDURE

This section outlines the procedures to be followed by the Producer in preparing the mixture design and by the Region Materials Engineer when reviewing mixture designs for volumetric and mechanical properties. For the design and review of recycled SHMA mixtures refer to Section VII. of this Method, "Recycled Hot Mix Asphalt Design Procedure." The Producer develops the mixture design according to AASHTO MP2, and PP28. This section outlines the procedures detailed in these AASHTO standards. As many variables as possible have been eliminated, to promote precise, accurate, and uniform testing.

A. Materials Selection

1. Aggregate Selection / Requirements

Aggregates must meet the requirements of §401-2.03, Aggregates, and additional project-specific consensus requirements for coarse aggregate angularity, fine aggregate angularity, flat-and-elongated particles, and sand equivalent. The aggregate consensus property requirements are based on estimated traffic loadings.

If an individual aggregate component does not meet the aggregate quality requirements, it is not necessarily precluded from use. However, its percentage of use in the total aggregate blend is limited as determined by the law of partial fractions. If an aggregate component's blend proportion is limited due to quality concerns, evaluate the Design Aggregate Structure selected to assure compliance with the aggregate consensus property requirements.

Note: ***If the coarse aggregate blend percentages are changed during production. Composite samples of the coarse aggregate should be tested to ensure that the minimum percent friction aggregate is present.***

Note: ***Pay particular attention to the coarse aggregate friction aggregate requirements for 12.5 mm and 9.5 mm top courses. The friction aggregate requirements may vary from project to project depending on the traffic volume and geographic location of a specific project.***

2. Performance Graded Binder Selection

A Performance Graded Binder (PG XX-YY) is denoted by the range of pavement temperatures, maximum to minimum, over which the binder is expected to provide acceptable performance. The maximum pavement temperature (XX) is equal to the average 7-day maximum pavement temperature 20 mm below the pavement surface. The minimum pavement temperature (-YY) is defined as the minimum pavement surface temperature. Using the Superpave weather database temperature variability is accounted for and a design reliability (or design risk) is assigned for each PGB.

A primary source, which appears on the Department's Approved List for Performance Graded Binders for Paving, shall certify that the PBG meets all requirements. This certification shall be provided by the last primary source to alter the PGB.

Note: ***The grade of PGB used on an individual project will be specified in the Contract Documents.***

Note: ***The Producer may change the source of PGB during production. When the PGB source is changed during production, the Producer must notify the Regional Materials Engineer of the change. Care should be taken to assure that the SHMA mixture is mixed and compacted at the recommended temperatures calculated on NYSDOT form BR 320 "Superpave Performance Graded Binder Temperature Viscosity Data."***

Note: ***The Producer must notify the Regional Materials Engineer, when using modified a PGB. Exercise extreme caution when changing modified PGBs.***

Note: ***Complete mix designs are not required for different specified PGB grades within the same compaction level (based on the estimated traffic loading in millions of 80 kN equivalent single axle loads). However, a new JMF is required, which references the original design and shows the PGB to be used. The new JMF will require plant verification by the Department.***

B. Design Aggregate Structure Selection

The Producer develops the mixture's design aggregate structure by analyzing at least three unique aggregate trial blends. This section details the procedures for analyzing Superpave Gyratory Compacted Specimens created with each trial blend at the same PGB content. The procedures for developing the aggregate trial blends are detailed in Section VI-A of this Method, "Plant Aggregate Gradation Analysis."

The Producer shall submit test results and data analysis from at least three aggregate trial blends. If the mixture design fails to be verified, the Regional Materials Engineer will use the trial blend data to analyze the design aggregate structure selected and propose potential adjustments.

All of the trial aggregate blends submitted must meet all of the aggregate quality requirements (see **Table 3 - Additional Aggregate Criteria**), design control points (see **Table 1 - Design Control Points**), restricted zone criteria (see **Table 2 - Restricted Zone**) for the specified estimated traffic loading and, if a friction course, the friction aggregate criteria for the estimated traffic volume. If any of the three trial blends do not meet these requirements, the design will be rejected.

Table 1 - Design Control Points

Standard Sieves (mm)	Percent Passing Criteria									
	Nominal Maximum Aggregate Size									
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
50.0		100.0								
37.5	100.0	90.0		100.0		100.0				
25.0	90.0		100.0	90.0	100.0	97.0				
19.0			90.0		100.0	90.0		100.0		
12.5					90.0		100.0	90.0		100.0
9.5							90.0		100.0	90.0
4.75									90.0	
2.36	41.0	15.0	45.0	19.0	49.0	23.0	58.0	28.0	67.0	32.0
0.075	6.0	0.0	7.0	1.0	8.0	2.0	10.0	2.0	10.0	2.0

Table 2 - Restricted Zone

Standard Sieves (mm)	Percent Passing Criteria									
	Nominal Maximum Aggregate Size									
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
4.75	34.7	34.7	39.5	39.5						
2.36	27.3	23.3	30.8	26.8	34.6	34.6	39.1	39.1	47.2	47.2
1.18	21.5	15.5	24.1	18.1	28.3	22.3	31.6	25.6	37.6	31.6
0.600	15.7	11.7	17.6	13.6	20.7	16.7	23.1	19.1	27.5	23.5
0.300	10.0	10.0	11.4	11.4	13.7	13.7	15.5	15.5	18.7	18.7

1. Mixture Aggregate Consensus Properties

The Producer determines the following aggregate consensus properties and reports the results on BR 266-270 (as appropriate), "Superpave Design Aggregate Structure Trial Blend Gradation Plot."

Table 3 - Additional Aggregate Criteria

Estimated Traffic, Million 80 kN ESALs	Coarse Aggregate Angularity		Fine Aggregate Angularity		Flat-and-elongated Particles	Sand Equivalent
	Depth from Surface					
	<100 mm	>100 mm(1)	<100 mm	>100 mm(1)		
< 0.3	85 / 80	85 / 80	-	-	-	40
0.3 to < 3.0	85 / 80	85 / 80	40	40	10	40
3.0 to < 10.0	85 / 80	85 / 80	45	40	10	45
10.0 to < 30.0	95 / 90	85 / 80	45	40	10	45
≥ 30.0	100/100	100/100	45	45	10	50

(1) If at least 75% of a layer is deeper than 100 mm below the pavement surface, the greater than 100 mm aggregate consensus properties apply for mixture design of that layer. This eliminates the more stringent aggregate consensus properties for most 37.5 mm base courses.

Coarse Aggregate Angularity. Coarse aggregate angularity is defined as the percent by mass of the aggregate particles larger than 4.75 mm with one or more fractured faces measured on the coarse particles of the blended aggregate by ASTM D5821. The criteria are presented as the minimum percent of coarse aggregate with the required number of fractured faces.

Fine Aggregate Angularity. Fine aggregate angularity is defined as the percent of air voids present in loosely compacted aggregate that passes the 2.36 mm sieve measured on the fine aggregate portion of the blended aggregate by AASHTO T 304. The criteria are presented as the minimum percent air voids required in loosely compacted fine aggregate.

***Note:** When the fine aggregate angularity of a natural sand or stone screenings from a crushed gravel source is evaluated, the specific gravity of the Method A blend must be determined for use in the test. When a manufactured sand or stone screenings from a crushed stone source is evaluated, use the specific gravity determined from the sampled material. If the specific gravity was assumed to be the same as the coarse aggregate from the same source, use the assumed value.*

Flat-and-elongated Particles. Flat-and-elongated particles are defined as coarse aggregate particles that have a ratio of maximum to minimum dimensions greater than five. The percentage of flat-and-elongated particles is measured on the portion of the blended aggregate retained on the 9.5 mm sieve by ASTM D4791. The criteria are presented as the maximum percent allowed by mass of flat-and-elongated particles.

Note: ***The maximum dimension is defined as the particles maximum length. The minimum dimension is defined as the particles maximum thickness (i.e., if the cross section of the particle is irregularly shaped, the maximum thickness is equal to the length of the short side of a rectangle large enough to contain this shape).***

Sand Equivalent. Sand equivalent is defined as the percent of the sand reading to the clay reading measured on the portion of aggregate that passes the 4.75 mm sieve by AASHTO T 176. The criteria are presented as the minimum percent sand equivalent required in the fine aggregate.

Note: ***Determination of the sand equivalent is not required on a routine basis. The Department believes the aggregates commonly used in New York will meet the most stringent Superpave consensus sand equivalent requirement. However, if performance problems are encountered the Department may require this testing to be performed.***

If any of the aggregate consensus quality requirements are not met, for any of the aggregates used in the proposed mixture design, the percent of use for those aggregates is limited in the total aggregate blend as determined by the law of partial fractions as detailed below in Appendix 1-B.4. of this Method, "Aggregate Consensus Properties Determination."

If the estimated total aggregate consensus property quality (EAQ) is below that specified in **Table 3 - Additional Aggregate Criteria**, reduce the percentage(s) batched for the failing aggregate(s) to bring the EAQ into conformance.

2. Friction Aggregate Requirements.

The Producer determines the aggregate blend to ensure adequate pavement friction, and reports that blend percentage on the BR 253-254, "Superpave Job Mix Formula." Friction requirements only apply to surface courses. There are four different friction aggregate requirements depending on the project's location and estimated traffic volume.

When the coarse aggregate is blended to meet the specified friction aggregate requirements, proportion the blend such that the percent non-carbonate is at least 2.5% (by mass with adjustments to equivalent volumes for materials of different specific gravities) above the minimum required, as determined from the target batching percentages listed on the JMF.

Note: ***When the coarse aggregate is blended to meet the specified friction aggregate requirement, the Producer should pay particular attention to the percent non-carbonate material in the friction aggregate. If the friction aggregate being blended is less than 100% non-carbonate, the percent friction aggregate of the blend must be increased proportionally, so the resulting mixture contains at least 2.5% more non-carbonate material than required.***

***Note:** The friction requirements for each project will be specified in the Contract Documents. The information included in this section is provided as a reference only, and does not supersede the criteria specified in the Contract Documents.*

a. Downstate, High Volume Roadways

Downstate High Volume - includes pavements in the area of the City of New York and the surrounding counties of Dutchess, Nassau, Orange, Putnam, Rockland, Suffolk, Sullivan, and Westchester Counties with design year two-way traffic AADTs exceeds 8,000 for 2 or 3 lanes, and 13,000 for more than three lanes.

Specification Requirements

For 12.5 mm F1 and 9.5 mm F1 nominal maximum size top course mixtures use crushed aggregate from an approved source, meeting one of the following requirements:

1. Limestone having an acid insoluble residue content of not less than 20.0%, excluding particles of chert and similar siliceous rocks.

2. Dolomite having an acid insoluble residue content of not less than 17.0%, excluding particles of chert and similar siliceous rocks.

3. Sandstone, granite, chert, traprock, ore tailings, slag or other similar non-carbonate materials. Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

4. Gravel, or a natural or manufactured blend of the following types of materials: limestone, dolomite, gravel, sandstone, granite, chert, traprock, ore tailings, slag or other similar materials, meeting the following requirements:

   12.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 30.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 95.0% of plus 9.5 mm particles must be non-carbonate.

   9.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 30.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 95.0% of plus 4.75 mm particles must be non-carbonate.

   Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

b. Upstate, High Volume Roadways

Upstate High Volume - includes pavements in all other areas in New York with design year two-way traffic AADTs exceeds 8,000 for 2 or 3 lanes, and 13,000 for more than three lanes.

Specification Requirements

For 12.5 mm F2 and 9.5 mm F2 top course HMA mixtures use crushed aggregate, from an approved source, meeting one of the following descriptions:

1. Limestone having an acid insoluble residue content of not less than 20.0%, excluding particles of chert and similar siliceous rocks.

2. Dolomite having an acid insoluble residue content of not less than 17.0%, excluding particles of chert and similar siliceous rocks.

3. Sandstone, granite, chert, traprock, ore tailings, slag or other similar non-carbonate materials. Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

4. Gravel, or a natural or manufactured blend of the following types of materials: limestone, dolomite (excluding Wappinger dolomite, as defined by the Department), gravel, sandstone, granite, chert, traprock, ore tailings, slag or other similar materials, meeting the following requirements:

   12.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 10.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 20.0% of plus 9.5 mm particles must be non-carbonate.

   9.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 10.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 20.0% of plus 4.75 mm particles must be non-carbonate.

   Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

5. Manufactured blend of Wappinger dolomite (as defined by the Department) and the following types of materials: gravel, sandstone, granite, chert, traprock, ore tailings, slag, or other similar materials meeting the following requirements:

12.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2mm particles must comprise a minimum of 30.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 95.0% of plus 9.5mm particles must be non-carbonate.

9.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 30.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 95.0% of plus 4.75 mm particles must be non-carbonate.

Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

c. Low Volume Roadways

Low Volume - includes all pavements in New York with design year two-way traffic AADTs less than 8,000 for 2 or 3 lanes, and 13,000 for more than three lanes.

Specification Requirements

For 12.5 mm F3 and 9.5 mm F3 top course HMA mixtures use crushed aggregate, from an approved source, meeting one of the following descriptions:

1. Limestone having an acid insoluble residue content of not less than 20.0%, excluding particles of chert and similar siliceous rocks.

2. Dolomite (excluding Wappinger dolomite, as defined by the Department).

3. Sandstone, granite, chert, traprock, ore tailings, slag or other similar non-carbonate materials. Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

4. Gravel, or a natural or manufactured blend of the following types of materials: limestone, dolomite (including Wappinger dolomite, as defined by the Department), gravel, sandstone, granite, chert, traprock, ore tailings, slag or other similar materials, meeting the following requirements:

   12.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 10.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 20.0% of plus 9.5 mm particles must be non-carbonate.

9.5 mm Nominal Maximum Size Aggregate Mixtures - Non-carbonate plus 3.2 mm particles must comprise a minimum of 10.0% of the total aggregate (by weight with adjustments to equivalent volumes for materials of different specific gravities). Additionally, a minimum of 20.0% of plus 4.75 mm particles must be non-carbonate.

Non-carbonate particles are defined as having a minimum acid insoluble residue content of 80.0%.

3. Trial Blend Binder Content Estimation.

Determine the trial blend PGB content according to Section 7 of AASHTO PP28, and report it on BR 276 "Superpave Design Aggregate Structure Trial Blend Compacted Specimen Volumetric Property Summary." If in the Producer's opinion the estimated trial blend binder content is inappropriate, an alternate PGB content may be used for the design aggregate structure phase of the mixture design. Care should be taken when selecting the trial blend PGB content. This point may be used in the Selection of the Design PGB Content phase of the mixture design, reducing the total number of specimens required to be compacted.

4. Data Analysis and Trial Blend Volumetric Properties @ 4% Air Voids Estimation

Calculate and analyze the specimen volumetric and mechanical data according to Section 9 of AASHTO PP28. The volumetric and mechanical properties for the compacted specimens are estimated at a nominal 96% G_{mm}, to provide a basis for comparison between the different trial blends. Determine the estimated design PGB content for each trial blend. This estimation is used to determine the four PGB contents evaluated in the Selection of the Design PGB Content phase of the mixture design.

5. Design Aggregate Structure Selection

Only aggregate trial blends which meet all volumetric and mechanical property requirements, estimated at 96% G_{mm}, can be selected as the design aggregate structure. If more than one aggregate trial blend meets all of the requirements, selection of the design aggregate structure is at the Producer's discretion.

Note: ***The Department recommends developing at least two aggregate trial blends meeting all volumetric and mechanical requirements. The Producer can then select the best design aggregate structure based on ease of production, ease of construction and economics.***

C. Design PGB Content Selection

The Producer shall submit the test results and data analysis from gyratory compacted specimens compacted using the selected design aggregate structure at four different PGB contents. From this data the Producer selects the design PGB content at the binder content

that results in a compacted density of 96% G_{mm} at the design number of gyrations (N_{design}). All volumetric and mechanical properties are checked at this PGB content to ensure that all requirements are met.

1. Trial Binder Contents Estimation

Evaluate four PGB contents according to Section 10 of AASHTO PP28. These include 0.5% below the estimated design PGB content, the estimated design PGB content, 0.5% and 1.0% above the estimated design PGB content. If the PGB content used to select the design aggregate structure is within ± 0.2% of one of the four binder contents determined above, it may be used and the other three trial binder contents adjusted accordingly. (i.e., Trial Blend PGB = 5.4%, Estimated Design PGB Content = 5.2%, Design Trial Point PGB Contents = 4.9%, 5.4%, 5.9%, and 6.4%)

Note: If in the Producer's opinion the maximum and minimum binder contents are unrealistic, the Producer should consult with the Regional Materials Engineer to establish revised design points.

2. Data Analysis and Curve Preparation

Calculate and analyze the specimen volumetric and mechanical data according to Section 9 of AASHTO PP28.

The Producer shall submit a BR 295 "Superpave Volumetric Property Curves," with a separate graphical plot for each of the following relationships:

a. $\%G_{mm}$ @ $N_{initial}$ and N_{design} vs. Performance Graded Binder Content

b. Voids in Mineral Aggregate (VMA) vs. Performance Graded Binder Content

c. Percent VMA filled with Binder (VFB) vs. Performance Graded Binder Content

d. Dust to Effective Binder Ratio ($P_{0.075}$ / P_{be}) vs. Performance Graded Binder Content

For each graph, plot the average value obtained at each PGB content, and fit the plotted values with a ***smooth curve*** that obtains the "best fit" for all values.

3. Design Performance Graded Binder Content Selection

The design PGB content is established at 96% G_{mm} (4% Air Voids) at N_{design} gyrations. All other volumetric and mechanical properties (see **Table 4 - Superpave Design Criteria**, and **Table 4.1 - Superpave Volumetric Design Criteria**) are checked at this binder content to assure that all criteria are met. If any of the criteria are not met at the selected design PGB content, a new design aggregate structure is required.

Prepare at least two specimens with the selected design aggregate structure at the design PGB content. Compact the specimens to $N_{maximum}$ gyrations. Determine the average

%Gmm of the specimens and confirm that it satisfies the design requirement given in **Table 4 - Superpave Design Criteria**. If the requirement is not met at the design PGB content, a new design aggregate structure is required.

Table 4 - Superpave Design Criteria

Property	Criteria
% Maximum Density at $N_{initial}$	See Table 4.1
% Maximum Density at N_{design}	= 96.0% of G_{mm}
% Maximum Density at $N_{maximum}$	≤ 98.0% of G_{mm}
Voids in the Mineral Aggregate, VMA	See Table 4.1
Voids Filled with Binder, VFB	See Table 4.1
Dust to Effective Binder Ratio, $P_{0.075}$	0.6 - 1.2$^{(1)}$

(1) The limits for dust to effective binder ratio are not required at this time. The Producer must determine the ratio during design, but the ratio is not required to be within the specified limits.

Table 4.1 - Superpave Volumetric Design Criteria

<table>
<tr><th rowspan="2">Estimated Traffic, ESALs x 10^6</th><th rowspan="2">%G_{mm} @$N_{initial}$</th><th colspan="2" rowspan="2">% Voids Filled with Binder</th><th colspan="5">% Voids in the Mineral Aggregate, minimum</th></tr>
<tr><th colspan="5">Nominal Maximum Aggregate Size (mm)</th></tr>
<tr><td></td><td></td><td>Min.</td><td>Max.</td><td>9.5</td><td>12.5</td><td>19.0</td><td>25.0</td><td>37.5</td></tr>
<tr><td>< 0.3</td><td>< 91.5</td><td>70$^{(2)(3)}$</td><td>80</td><td rowspan="5">15.0</td><td rowspan="5">14.0</td><td rowspan="5">13.0</td><td rowspan="5">12.0</td><td rowspan="5">11.0</td></tr>
<tr><td>0.3 to < 3.0</td><td>< 90.5</td><td>65$^{(3)}$</td><td>78</td></tr>
<tr><td>3.0 to < 10.0</td><td rowspan="3">< 89.0</td><td rowspan="3">65$^{(1)(3)}$</td><td rowspan="3">75$^{(1)}$</td></tr>
<tr><td>10.0 to < 30.0</td></tr>
<tr><td>≥30.0</td></tr>
</table>

(1) For 9.5 mm nominal maximum size mixtures, the VFB range is 73% to 76% for design traffic levels ≥3.0 million ESALs.

(2) For 25.0 mm nominal maximum size mixtures, the lower limit of the VFB is 67% for design traffic levels < 0.3 million ESALs.

(3) For 37.5 mm nominal maximum size mixtures, the lower limit of the VFB is 64% for all design traffic levels.

D. Moisture Susceptibility Testing

1. Criteria for Use

Moisture susceptibility testing shall only be performed if it is required in the Contract documents. This test will be used at the Regional Materials Engineer's discretion, during design, or routine production when an identified problem exists with an aggregate source or when a substantial change is made to a design. If the asphalt binder source is changed for a design that was tested for moisture susceptibility, that mixture may be required to be tested again, at the Regional Materials Engineer's discretion.

2. Procedure

Prepare at least six gyratory compacted specimens, proportioned according to the JMF. Batch and compact all specimens according to Section VI-C. of this Method, "Specimen Batching and Compaction." Specimen size is dependent on the nominal maximum aggregate size. Use a specimen size of 100 mm diameter by 65 mm height for 9.5 mm 12.5 mm 19.0 mm and 25.0 mm mixtures. Use a specimen size of 150 mm diameter by 65 mm height for 37.5 mm mixtures.

Determine the tensile strength ratio (TSR) of each specimen according to ASTM D4867, except as modified in this section. The specimens may be fabricated up to 96 hours before tensile strength ratio (TSR) testing. Use the freeze-thaw conditioning cycle in accordance with Note 5 of ASTM D4867.

If the TSR of the SHMA gyratory specimens is less than 80%, as required in AASHTO MP2, corrective action is required. When corrective action is necessary, any changes made to the design must be noted on the JMF, and all other volumetric and mechanical properties must be evaluated for compliance with requirements. After corrective action has been taken, retest the mixture according to this section.

Note:* *Corrective action to improve the moisture susceptibility can include the use of anti-strip additives (either liquid or hydrated lime) or blending of other aggregate sources.

VI. SPECIMEN FORMULATION

This section outlines the procedures to develop the design aggregate structure for an SHMA mixture. The Producer develops the design aggregate structure. The Regional Materials Engineer reviews the design aggregate structure for conformance to requirements. This section also outlines the procedure for batching and compaction of SHMA mixture test specimens according to AASHTO TP 4-93 and PP 2-94. As many variables as possible have been eliminated to promote precise, accurate, and uniform testing. When formulating specimens for

SHMA mixtures containing RAP, refer to Section VIII. of this Method, "Recycled Hot Mix Asphalt Specimen Formulation."

Note: The Department recommends that at least one aggregate specific gravity test be performed during the production season. This will provide the Producer with current data on the aggregate's volumetric properties before developing new designs.

Note: The Producer may determine the coarse aggregate specific gravity on a blend of materials from stockpiles (i.e., 1A's, 1's, and 2's) of the same source, in-lieu of performing tests on each individual stockpile.

Note: Fine aggregate specific gravity testing is not required on stone screenings and manufactured sands from crushed stone sources. The specific gravity of these materials is assumed to be the same as the average coarse aggregate specific gravity from the same source.

A. Plant Aggregate Gradation Analysis

The analysis of aggregate gradations and the blending of aggregate to obtain the desired gradation are important steps in the SHMA design process. Select an aggregate gradation that conforms to the control points and restricted zone criteria, and yields a mixture that meets all volumetric requirements.

This section outlines the methods of analyzing aggregate for an SHMA mixture design at two types of production facilities: batch plants and drum plants; each requires a different method of analysis. Batch plants incorporate their own aggregate screening system. Drum mix plants control aggregate gradation through the gradation of stockpiles. The requirements for SHMA design aggregate analysis for each type of plant system are outlined separately.

Note: The procedure for each type of facility is illustrated in the sample mix design contained in Appendix 3.

1. Batch Plants

Obtain an aggregate history of the materials used at each batch plant, consisting of at least ten ***washed*** gradations performed according to AASHTO T 27 and T 11. Attention must be given to ensure that the gradation history and aggregate samples are representative of normal production.

Create a table, from the aggregate history, showing the percent passing each sieve for each individual aggregate component (i.e., No. 1, No. 1A, screenings or blended fines). From this table, determine the average gradation of each aggregate component. When aggregate blends are used, document the approximate cold feed blend percentages.

Note: Plants equipped to re-add all fines from the dust collection system or varying amounts of dust collector fines should be carefully analyzed when evaluating the aggregate history. This aspect should be held constant for

the gradation history average and when obtaining aggregate samples for the preparation of SHMA specimens.

Once the average gradation of each aggregate component is determined from the aggregate gradation history, a combined blend target gradation is prepared by applying the blend proportion to the average gradation history percent passing each sieve for each aggregate component. The actual blend target gradation is the total of this calculation for each sieve size for each aggregate component in the mixture.

For each aggregate component, calculate the average individual percent retained for the size fractions shown in Section VI-B. of this Method, "Aggregate Preparation," and determine the batching masses for the gyratory compacted specimens and mixture maximum specific gravity samples. The details of specimen batching are explained in Section VI-C. of this Method, "Specimen Batching and Compaction."

The aggregate cold feed blend proportions used to develop the average gradation history are also used during SHMA mixture production. During production, small adjustments to the aggregate cold feed blend proportions are allowed to compensate for variations in aggregate moisture content, slight variations in cold bin aggregate gradations, etc.

The batch plant aggregate stockpiles are also evaluated according to the provisions detailed for drum mix plants. The results of this analysis are used to determine the aggregate consensus properties, and may result in a restriction in the blend proportion of one or more aggregate components. This analysis does not require washed gradations.

2. Drum Mix Plants

Obtain an aggregate history of the materials used at each drum mix plant, consisting of at least ten ***washed*** gradations performed according to AASHTO T 11 and T 27. Create a table, from the aggregate history, showing the percent passing each sieve for each individual aggregate component (i.e., No. 1, No. 1A, screenings or blended fines).

Once the average gradation of each aggregate component is determined from the aggregate gradation history, a combined blend target gradation is prepared by applying the blend proportion to the average gradation history percent passing each sieve for each aggregate component. The actual blend target gradation is the total of this calculation for each sieve size for each aggregate component in the mixture.

For each aggregate component, calculate the average individual percent retained for the size fractions shown in Section VI-B. of this Method, "Aggregate Preparation," to determine the batch masses for the gyratory compacted specimens and mixture maximum specific gravity samples. The details of specimen batching are explained in Section VI-C. of this Method, "Specimen Batching and Compaction."

B. Aggregate Preparation

The Producer shall obtain representative aggregate samples according to Materials Method 5.0 M. Obtain a sufficient sample quantity of aggregate for the Producer to prepare a minimum of sixteen gyratory compacted specimens and sixteen maximum specific gravity samples, and for NYSDOT to prepare a minimum of six gyratory compacted specimens and six maximum specific gravity samples. A total combined aggregate mass of 130 kg should be sufficient. Since additional testing is often required, it is recommended that additional aggregate components be obtained when sampling.

Note: NYSDOT recommends batch plant aggregate samples be obtained from individual hot bins. However, this practice is not required.

Separate aggregate samples to be used in the batching and compaction of gyratory compacted specimens and mixture maximum specific gravity samples into the size fractions listed in **Table 5 - Aggregate Size Fractions**.

Note: At the discretion of the Producer, aggregates may be broken down into individual screen sizes to perform the mixture design. However, NYSDOT will verify the mixture design using the size fractions listed in Table 5 - Aggregate Size Fractions.

Table 5 - Aggregate Size Fractions

Size Fraction
+ 37.5 mm
25.0 mm to 37.5 mm
19.0 mm to 25.0 mm
12.5 mm to 19.0 mm
9.5 mm to 12.5 mm
4.75 mm to 9.5 mm
2.36 mm to 4.75 mm
- 2.36 mm

C. Specimen Batching and Compaction

The Producer shall prepare at least two gyratory compacted specimens and two mixture maximum specific gravity samples for each design aggregate trial blend and each PGB content used to determine the design PGB content. Condition all mixtures according to AASHTO PP 2 and compact all mixtures according to AASHTO TP 4.

Note: ***NYSDOT recommends making three gyratory specimens as a precaution against potential error.***

The mixing and compaction temperatures are determined based on the range of temperatures that result in apparent viscosities of 0.17 ± 0.02 Pa·s and 0.28 ± 0.03 Pa·s respectively when measured according to ASTM D4402. This information should be available from the refinery or terminal distributing the PGB and must be reported on BR-320 "Performance Graded Binder Temperature Viscosity Data."

Note: ***The manufacturer of modified PGBs may recommend mixing and compaction temperatures different from those determined based on the apparent viscosities listed above. Report the manufacturer-recommended mixing and compaction temperatures on BR 320 "Superpave Performance Graded Binder Temperature Viscosity Data."***

Note: ***The Producer may determine the mixing and compaction temperatures graphically according to Asphalt Institute Technical Bulletin, "Laboratory Mixing and Compaction Temperatures." Report the results on BR 320 "Superpave Performance Graded Binder Temperature Viscosity Data."***

If the mixing bowl or the short term aging pan is being used for the first time, the inside should be lightly coated, using a similar SHMA mixture, before batching or aging the first specimen. The mixing bowls, compaction molds and short term aging pans should be clean at the beginning of each SHMA mixture design.

1. Batching

Batch gyratory compaction specimens and mixture maximum specific gravity samples by aggregate component and size fraction. Doubled batching of specimens is allowed at the Producer's discretion. NYSDOT recommends that the specimens be mixed individually to reduce the potential for error.

Note: ***The Producer may add minus 0.075 mm size material to account for plant fluctuations. However, the aggregate gradation after the addition must meet all control points and restricted zone criteria. The target value for the 0.075 mm material shown on the JMF should be the actual amount of 0.075 mm material batched, less any additional 0.075 mm material added.***

The required gyratory compacted specimen size is 115 mm ± 5 mm in height by 150 mm in diameter. The mixture maximum specific gravity sample size varies depending on the nominal maximum aggregate size of the mixture being tested, as detailed in AASHTO T209. Use a 3.000 kg sample for 37.5 mm nominal maximum size mixtures.

Note: ***The gyratory compaction specimen mass depend on the specific gravity of the aggregate.***

The specific composition (i.e., the component size fraction batch masses) of each gyratory compacted specimen and mixture maximum specific gravity sample is determined according to the following procedure.

a. Estimate the total gyratory compacted specimen mass required to produce a specimen of the dimensions detailed above. The mixture maximum specific gravity sample size is predetermined based on the nominal maximum aggregate size of the mixture.

b. Determine the specimen's PGB content (see Section V-B. 3. of this Method, "Trial Blend Binder Content Estimation," or Section V-C. 1. of this Method, "Trial Binder Contents Estimation").

c. Determine the mass of the specimen's PGB content by multiplying the predetermined PGB content percentage by the total mass of the specimen from above (i.e., at 5.5% PGB, then 0.055 x 5000.0 = 275.0 grams of PGB).

Note: ***During the selection of the design PGB content for the selected aggregate structure phase of the mixture design it is recommended that a constant aggregate batch mass be used for each design point and that the PGB batch mass be adjusted to simplify the batching procedure. If this procedure is used, the mean of the four selected PGB contents should be used to determine the aggregate batch mass. The required PGB batch mass can be determined from equation 1:***

$$PGBM = \frac{TABM}{1 - PGB_{estimated}} - TABM \qquad (1)$$

where:

$PGBM$	=	***Total PGB Batch Mass, (g)***
$TABM$	=	***Total Aggregate Batch Mass, (g)***
$PGB_{estimated}$	=	***Estimated Performance Graded Binder content (-0.5% below the estimated design PGB content, the estimated design PGB content, +0.5 and +1.0 % above the estimated design PGB content)***

d. Determine total mass of aggregate (equation 2):

$$TMA = TSM - PGBM \qquad (2)$$

where:

TMA	=	Total Mass of Aggregate, (g)
TSM	=	Total Specimen Mass, (g)
PGBM	=	Total Performance Graded Binder Mass, (g)

e. Determine the total mass (grams batched) of each individual aggregate component by multiplying its pre-determined blend proportion by the total mass of aggregate in the specimen.

f. For each aggregate component, determine the batch mass for each aggregate size fraction by multiplying the average percent retained in each size fraction by the total mass (grams batched) for that aggregate component. Any difference between the total batch mass and the cumulative grams batched of all size fractions of that component should be compensated for in the size fraction having the most material.

g. Using a scale meeting the requirements listed in **Table 6 - Scale Requirements**, place the batch mass of each aggregate component size fraction into a suitable container. Determine the mass of each material, beginning with the highest percentage material and working toward the lowest percentage material.

Table 6 - Scale Requirements

Test Mass (grams)	Accuracy Requirements
0 - 200	± 0.1 g
201 - 2000	± 0.05 % of test load
2001 and greater	± 1.0 g

h. If the batch mass of each aggregate component was measured individually, combine all aggregate components to determine the total aggregate specimen mass.

Note: ***If the total mass of aggregate batched is not within ± 10.0 grams of target, or the mass of PGB batched is not within ± 1.0 gram of target, discard the specimen.***

2. Compaction

The required gyratory compactive effort depends on the estimated traffic loading in millions of 80 kN ESALs, **Table 7 - Design Number of Gyrations**. The design estimated traffic loading is provided in the Contract Documents.

Table 7 - Design Number of Gyrations

Estimated Traffic, Million 80 kN ESALs	<0.3	0.3 to < 3.0	3.0 to <10.0	10.0 to < 30.0	≥30.0
$N_{initial}$	6	7	8	8	9
N_{design}	50	75	100	100	125
$N_{maximum}$	75	115	160	160	205

Note: ***The Department recommends the following procedure for loading the gyratory compactor mold. The Department will follow this procedure when monitoring plant produced SHMA for quality assurance.***

After short term aging, place the SHMA sample onto a sheet of medium mass (23.6 kg) brown craft paper (about 900 mm x 900 mm), roll opposite ends of the paper to form a tube and fold over the ends of the tube to contain the sample. Place the specimen in an appropriate size pan and pierce each end of the closed paper roll with a thermometer. Heat the specimen to mixture temperature, if necessary.

Obtain a gyratory specimen mold and base/top plate, heated to compaction temperature. Place a paper disk in the bottom of the mold. Hold the paper roll vertically over the mold with the lower end slightly below the top of the mold. Drop the sample into the mold from the paper roll in a single drop by releasing the lower end of the paper roll. Level the top of the mix sample and place a paper disk and mold top plate (if required) on top of the mold. Place the mold in the gyratory compactor and compact to the required number of gyrations.

VII. RECYCLED HOT MIX ASPHALT DESIGN PROCEDURE

This section outlines the procedures to be followed by the Producer in preparing the recycled mixture design and by the Region Materials Engineer when reviewing recycled mixture designs for volumetric and mechanical properties. The Producer develops the Superpave recycled mixture design according to AASHTO MP 2 and AASHTO PP 28. This section outlines the procedures detailed in these AASHTO standards. As many variables as possible have been eliminated, to promote precise, accurate, and uniform testing.

The Superpave HMA design system is not significantly altered by the inclusion of RAP. The overall process remains the same; however, extra procedures are required to accommodate the use of RAP. RAP is handled as a stockpile material and is subject to all aggregate consensus property requirements. A Superpave recycled HMA mixture consists of RAP, virgin aggregate and virgin PGB.

The maximum RAP blend proportion for 9.5 mm, 12.5 mm, 19.0 mm and 25.0 mm nominal maximum size mixtures is ***20.0%*** by mass of the total mixture. The maximum RAP blend proportion mixtures for 37.5 mm mixtures is ***30.0%*** by mass of the total mixture. No adjustment is made to the PGB grade to account for the hardness of the RAP binder.

Figure 1 - Superpave Recycled Mixture Diagram

<table>
<tr><td colspan="4">←------------------------------ Total Mixture ------------------------------→</td></tr>
<tr><td colspan="2">←---------- Total Aggregate----------→</td><td colspan="2">←------- Total Binder Content (P_{tb})--------→</td></tr>
<tr><td rowspan="2">← Virgin Aggregate→</td><td colspan="2">←----------- Total RAP Content (P_r)----------→</td><td rowspan="2">←-Virgin PGB -→ Content (P_b)</td></tr>
<tr><td>← RAP Agg. Content →</td><td>←RAP Binder Content (P_{rb})→</td></tr>
</table>

A. MATERIALS SELECTION.

1. Aggregate Selection

Follow Section V-A. 1. of this Method, "Aggregate Selection / Requirements." All requirements apply to RAP aggregate.

2. Performance Graded Binder Selection

Select the PGB according to Section V-A. 2. of this Method, "Performance Graded Binder Selection."

B. RAP PROPERTIES DETERMINATION.

1. Obtaining RAP Samples

It is essential that all tests are performed using samples that accurately represent the stockpile from which they are taken. Proper sampling is critical when working with RAP, due to the wide variety of sources from which RAP is obtained. Obtain all samples according Materials Method 5.0 M.

All RAP samples must represent the material that will be introduced into the mixing unit. RAP stockpile samples must be processed to remove all material larger than the scalping screen which will be used during production and dried to a constant mass before analysis or specimen formulation can begin. Samples should be dried immediately before being heated for use. Any samples that are heated and allowed to cool below mixing temperature prior to use must be discarded.

2. RAP Binder Content Determination

Determine the asphalt binder content of each RAP sample as described in Section VIII-A. of this Method, "Plant Aggregate Gradation and RAP Binder Content Analysis."

C. DESIGN AGGREGATE STRUCTURE SELECTION.

Follow Section V-B. of this Method, "Design Aggregate Structure Selection," except as modified below.

1. Recycled Mixture Aggregate Consensus Properties

Determine the aggregate consensus properties described in Section V-B. 1. of this Method, "Mixture Aggregate Consensus Properties," for all individual aggregate components, including RAP aggregate recovered by extraction, and report all results on BR 266-270 (as appropriate), "Superpave Design Aggregate Structure Trial Blend Gradation Plot."

2. Trial Blend Total Binder Content Estimation.

Determined the trial blend total binder content (virgin PGB plus RAP binder) according to Section 7 of AASHTO PP28, as if the mixture did not contain RAP, and report it on BR. 277, "Superpave Design Aggregate Structure Trial Blend Compacted Specimen Volumetric Property Summary for Recycled Mixtures." If in the Producer's opinion the estimated trial blend total binder content is inappropriate, an alternate trial blend total binder content may be used for the design aggregate structure phase of the mixture design. Care should be taken in selecting the trial blend total binder content. This point may be used in the selection of the design PGB content phase of the mixture design, reducing the total number of specimens required to be compacted.

Determine the RAP blend proportion of the total mixture (equation 3). Calculate the trial blend virgin PGB content (equation 4).

$$P_r = \frac{(1 - P_{tb})*PB_r}{1 - P_{rb}} \qquad (3)$$

where:

PB_r	=	Blend Proportion of the RAP stockpile, as determined by Aggregate Consensus Properties.
P_r	=	RAP blend proportion, percent by total mass of mixture,
P_{rb}	=	RAP binder content, percent by mass of RAP that is binder,
P_{tb}	=	Total binder content, percent by mass of mixture.

Note: ***Equation 3 is only necessary if the RAP aggregate blend proportion (PB_r) is limited due to aggregate consensus property concerns. The RAP aggregate meets all aggregate consensus properties, the Producer may choose any RAP blend proportion (P_r) which is $\leq$ 20.0%.***

Note: ***The maximum RAP blend proportion (P_r) is 20.0%. If P_r, as calculated by equation 3, is greater than 20.0%, a virgin RAP aggregate blend proportion must be chosen, a new Design Aggregate Structure selected, and a new trial batch binder content estimated.***

$$P_b = P_{tb} - (P_r * P_{rb}) \qquad (4)$$

where:

P_b = Virgin Performance Graded Binder, % by total mass of mixture.

3. Data Analysis and Trial Blend Volumetric Properties @ 4% Air Voids Estimation

Calculate and analyze the specimen volumetric and mechanical data according to Section 9 of AASHTO PP28. The volumetric and mechanical properties for the compacted specimens are estimated at a nominal 96% G_{mm}, to provide a basis for comparison between the different trial blends. Determine the estimated design total binder content for each trial blend. This estimation is used to determine the four total binder contents evaluated in the, "Selection of the Design Total Binder Content," phase of the mixture design.

4. Recycled Design Aggregate Structure Selection

Follow Section V-B. 5. of this Method, "Design Aggregate Structure Selection."

D. Design Total Binder Content Selection

The Producer shall submit the test results and data analysis from gyratory compacted specimens compacted using the selected design aggregate structure at four different total binder contents. The RAP blend proportion is held constant for all four trial blends. Alterations to the total binder content are made by increasing the percent virgin PGB and decreasing the percent virgin aggregate. From this data the Producer determines the design total binder content. The design total binder content is selected at the binder content that results in a compacted density of 96% G_{mm} at N_{design} gyrations. All other volumetric and mechanical properties are checked at this binder content to ensure that all requirements are met.

1. Trial Total Binder Contents Estimation

Evaluate four different total binder contents according to Section 10 of AASHTO PP28. These include 0.5% below the estimated design total binder content, the estimated design total binder content, 0.5% and 1.0% above the estimated design total binder content. If the total binder content used during the selection of the design aggregate structure is within ± 0.2% to one of the four binder contents determined above, it may be used and the other three trial binder contents adjusted accordingly. (i.e., Trial Blend PGB = 5.4%, Estimated Design Total Binder Content = 5.2%, Design Trial Point Total Binder Contents = 4.9%, 5.4%, 5.9%, and 6.4%)

***Note:** If in the Producer's opinion the maximum and minimum binder contents are unrealistic, the Producer should consult with the Regional Materials Engineer to establish revised design points.*

2. Data Analysis and Curve Preparation

Follow Section V-C. 2. of this Method, "Data Analysis and Curve Preparation," except plot all properties versus total binder content.

3. Design Total Binder Content Selection

The design total binder content is established at 96% G_{mm} (4% Air Voids) at N_{design} gyrations. Show this binder content on form BR 295 "Superpave Volumetric Property Curves." All other volumetric and mechanical properties (see **Table 4 - Superpave Design Criteria**, and **Table 4.1 - Superpave Volumetric Design Criteria**) are checked at this binder content to assure that all criteria are met. If any of the criteria are not met at the selected design total binder content, a new design aggregate structure is required.

Prepare at least two specimens with the selected design aggregate structure at the design Total Binder content. Compact the specimens to $N_{maximum}$ gyrations. Determine the average %Gmm at of the specimens and confirm that it satisfies the design requirement given in **Table 4 - Superpave Design Criteria**. If the requirement is not met at the design PGB content, a new design aggregate structure is required.

E. Moisture Susceptibility Testing

Follow Section V-D. of this Method, "Moisture Susceptibility Testing."

VIII. RECYCLED HOT MIX ASPHALT SPECIMEN FORMULATION

This section outlines the procedures to develop the design aggregate structure for an SHMA recycled mixture. The Producer develops the design aggregate structure. The Regional Materials Engineer reviews the design aggregate structure for conformance to requirements. This section also outlines the procedure for batching and compaction of Superpave recycled mixture test specimens according to AASHTO TP 4 and PP 2. As many variables as possible have been eliminated to promote precise, accurate, and uniform testing.

A. Plant Aggregate Gradation and Rap Binder Content Analysis

Follow Section VI. A. of this Method, "Plant Aggregate Gradation Analysis," except as modified herein.

Analyze each sample of RAP, to determine its binder content according to Materials Method 5.0 M. Determine the effective specific gravity of the RAP aggregate and use this value as the Bulk specific gravity of the RAP aggregate for calculation purposes.

Note: ***The Ignition Method may be used to recover RAP aggregate. However, the Regional Materials Engineer may perform chemical extraction for a specific RAP stockpile, if there is evidence that the ignition method causes a change in the aggregate consensus properties of that stockpile. If chemical extraction confirms that the consensus properties are changed during ignition, chemical extraction will be required.***

B. Aggregate and RAP Preparation

The Producer shall obtain representative aggregate samples according to Materials Method 5.0 M. Obtain a sufficient quantity of aggregate for the Producer to prepare a minimum of sixteen gyratory compacted specimens and sixteen maximum specific gravity samples, and for NYSDOT to prepare a minimum of six gyratory compacted specimens and six maximum specific gravity samples. A total combined aggregate and RAP mass of 130 kg should be sufficient. Since additional testing is often required, it is recommended that additional components be obtained when sampling.

Separate aggregate samples to be used in the formulation of gyratory compacted specimens and mixture maximum specific gravity samples into the size fractions listed in **Table 5 - Aggregate Size Fractions**.

Note: ***At the Producer's discretion aggregates may be broken down into individual screen sizes to perform the mixture design. However, NYSDOT will verify the mixture design using the size fractions listed in Table 5 - Aggregate Size Fractions.***

RAP samples used in the formulation of gyratory compacted specimens and mixture maximum specific gravity samples must reflect the material that will be introduced into the mixing unit. The RAP must be processed to remove all material larger than the scalping screen which will be used during production and heated to mixing temperature. To avoid hardening of the RAP binder, heating times and temperatures should be kept to a minimum. Once a RAP sample has been heated to mixing temperature, it must be used within 1 hour. RAP samples may not be heated more than once.

C. Specimens Batching and Compaction

Follow Section VI. C. of this Method, "Specimen Batching and Compaction," with the following additions.

1. The aggregate gradation history should include the binder content of each RAP sample taken for gradation analysis.

2. During the preparation and specimen formulation process the RAP is handled as a composite material. Do not extract the RAP binder from the RAP aggregate and handle the two materials separately.

3. Batch the RAP as the last aggregate component, prior to batching the virgin PGB.

IX. VERIFICATION

The Producer shall submit, to the Regional Materials Engineer:

1. a complete SHMA mixture design, including the analysis of three distinct aggregate blends and the determination of the optimum PGB content through the analysis of four different binder contents;

2. a sufficient sample of aggregate for laboratory verification purposes;

3. a minimum of six, 1 liter, PGB samples from the plant, the terminal, or the refinery.

Divide the PGB equally into six clean, sealed containers, suitable for heating. Label the containers with the source of the PGB, the type of modification if any, the date of sampling, and the performance grade designation. If the PGB is modified in any way, the samples must be accompanied by the appropriate Materials Safety Data Sheet.

Note: When sampling the PGB, use the approved sampling valve and drain off at least 4 liters from the spout before sampling.

Separate the aggregate sample into the size fractions given in **Table 5 - Aggregate Size Fractions**. Place each aggregate size fraction in a separate substantial, sealed container. Label each container with the aggregate source number, aggregate size designation, and size fraction.

NYSDOT will review the submitted SHMA design and either assign Verification Status or reject the mixture design within twenty-eight days of the date of submission. When a design is submitted during the paving season, NYSDOT will review the design and assign Verification Status or reject the design within fourteen days of the date of submission.

A. MIXTURE DESIGN REVIEW AND LABORATORY VERIFICATION

1. The Regional Materials Engineer will review the submitted SHMA design to determine if:

   a. A complete design has been prepared according to this Method, meeting all volumetric criteria and aggregate consensus property requirements;

b. The specific production facility is using the same aggregate source(s) for production as were used for the design;

c. The SHMA gradation is representative of actual plant production and the aggregate target values listed on the JMF correspond to the gradation appearing on the BR 266-270 (as appropriate), "Superpave Design Aggregate Structure Trial Blend Gradation Plot," for the selected aggregate blend;

d. No excessive variation exists in the compacted specimen's bulk specific gravity or the mixture's maximum specific gravity data at the binder contents evaluated;

e. No major renovations to the production facility have been completed since the last mixture design was assigned Production Status;

f. The submitted design was completed according the appropriate procedures and contains a reasonable PGB content for the materials used and the design traffic loading level specified;

g. The Producer and the specific mix designer have both submitted previous designs that were assigned and have maintained Production Status.

2. Based on this review, the Regional Materials Engineer will do one of the following.

   a. Assign Verification Status to the design;

   b. Reject the design for being incomplete;

   c. Reject the design for not meeting the mixture volumetric criteria or the aggregate consensus property requirements;

   d. Determine the design does not meet the criteria listed above and conduct (or have conducted on his behalf) a laboratory verification. The Regional Materials Engineer may wave the laboratory verification requirement and assign Verification Status to the design. The Regional Materials Engineer is solely responsible for making this determination.

The tolerances listed in **Table 8 - Laboratory Verification Tolerances** will be used in determining laboratory verification of a submitted design.

Table 8 - Laboratory Verification Tolerances

Design Criteria	Laboratory Verification Tolerance
Air Voids, V_a	± 1.0 %
Voids in the Mineral Aggregate, VMA	See Table 4.1
Voids Filled with Binder, VFB	See Table 4.1
Dust to Effective Binder Ratio, $P_{0.075\,mm}/P_{be}$	See Table 4.1
% Density at $N_{maximum}$	< 98.0 %
% Density at $N_{initial}$	See Table 4.1

3. Based on the results of the laboratory verification, the Regional Materials Engineer do one of the following

   a. Assign Verification Status to the design;

   b. Reject the design for not complying with the volumetric property requirements. At this point a complete redesign is required. As a minimum, this will consist of analyzing three distinct aggregate blends and determining the design PGB content through the analysis of four design points. If the same aggregate sources are used in the redesign, only one additional aggregate blend is required. When the redesign is submitted, the Mixture Design Verification Procedure starts at the beginning of the verification process.

B. PLANT VERIFICATION

Once the submitted mixture design has been assigned Verification Status by the Regional Materials Engineer the Producer must plant verify the design as described below. The tolerances shown in **Table 9 - Production Volumetric Tolerances**, and **Table 10 - Production Gradation Tolerances**, apply during verification status production.

1. Initial Production Notification

The Producer must notify the Regional Materials Engineer and the Contractor at least 24 hours before initial production. If this notice is not given, mixture verification will not begin, and any material shipped to Department projects will not be accepted.

2. Supplying Verification Status Material to Department Projects

SHMA produced during the plant verification of a Verification Status design may be supplied to Department projects. All efforts should be made to limit the use of Verification Status production material to non-mainline areas; however, mainline is not specifically excluded. The Regional Materials Engineer will notify the

Engineer-In-Charge prior to the shipment of material during Verification Status production.

3. Quality Control During Verification Status Production

The Producer must monitor all volumetric properties and aggregate gradations during Verification Status production according to §402 - Quality Control Asphalt Concrete - General. Obtain quality control samples using procedures outlined in Materials Procedure 94-4, "Testing Frequencies using Random Sampling at a Hot Mix Asphalt (HMA) Plant." Compact all specimens to N_{design} gyrations.

The Producer is authorized to make necessary adjustments during Verification Status production to bring the design into conformance with all specified requirements.

During Verification Status production, the Producer shall fax a copy of each day's BR 328 "Computation of Volumetric Mix Proportions," to the Regional Materials Engineer before 6:00 a.m. of the following day. Clearly note the total metric tons of production for each day and the cumulative total metric tons of Verifications Status production.

Note:* *If the SHMA mixture design contains aggregates that do not meet the specified aggregate consensus properties and adjustments are made to the percentages of any aggregate's blend proportion as shown on the JMF to improve the quality of the plant produced mixture, the Producer must recalculate the blend EAQ(s) as outlined in Section V-B. 1. of this Method, "Mixture Aggregate Consensus Properties," to insure total blend still meets the consensus property requirements.

4. Determining QAFs for Verification Status Material

For each day of Verification Status production, the Department will determine the daily production QAF according to §402 -Quality Control Asphalt Concrete - General.

5. Assigning Production Status

Verification Status production will continue until the end of the third production day, or the end of the day in which total production of the mixture reaches 2700 Mg, whichever period is longer. At the successful conclusion of Verification Status production, the Regional Materials Engineer will assign Production Status to the mixture design.

If the daily QAF yielded by the required test results, is below 1.00 for every day of Verification Status production, the design will be rejected.

Note:* *The Regional Materials Engineer will assign Production Status or reject the design based on the daily QAF as determined in Table 402-3 "Air Voids in Plant Mixture (Volumetric Designs)." This value may be less than the QAF used for payment during Verification Status production.

At any time before the Regional Materials Engineer assigns Production Status the Producer may declare the design rejected. Once the design is rejected, no additional changes are allowed and a complete redesign is required. As a minimum, the redesign must include the analysis of three distinct aggregate blends and the determination of the design PGB content through the analysis of four design points. If the same aggregate sources are used in the redesign, only one additional aggregate blend is required. When the redesign is submitted, the Mixture Design Verification Procedure starts at the beginning of the verification process.

X. MONITORING PLANT MIXTURE PROPERTIES

Once the mixture design has been assigned Production Status, the tolerances listed in **Table 9 - Plant Volumetric Production Tolerances** and **Table 10 - Plant Gradation Production Tolerances** will be applied to monitor the mixture.

Note: The aggregate specific gravities used to calculate mixture volumetric properties during mixture verification and plant production monitoring will be based on the running average of the last six tests (or less) performed on each source. If no previous specific gravity testing has been performed, the previously untested aggregate used in the mixture design shall be tested and the resultant values used.

Table 9 - Volumetric Production Tolerances

Volumetric Properties	Plant Production Tolerance(1)		
Air Voids, V_a	---		
Voids in the Mineral Aggregate, VMA	- 1.0 %		
Voids Filled with Binder, VFB	± 5.0 %		
Dust to Effective Binder Ratio, $P_{0.075\ mm}/P_{be}$ (2)	± 0.1		
% Density at $N_{initial}$	Estimated Traffic, Million 80 kN ESALs		
	< 0.3	< 3.0	≥ 3.0
	< 92.0 %	< 91.0 %	< 89.5

(1) These tolerances are applied to the specified criteria.
(2) The Dust to Effective Binder Ratio is not required at this time.

The Production Tolerances listed in **Table 10 - Plant Gradation Production Tolerances** will be applied to the JMF target values.

Table 10 - Production Gradation Tolerances

Sieve Size (mm)	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.180	0.600	0.300	0.150	0.075
Tolerance	±5	±5	±5	±5	±5	±5	±5	±5	±5	±5	±5	±5

The production gradation tolerance range will be permitted to exceed the control points and enter the restricted zone.

Note: ***Although the control point for the percent passing the 25.0 mm sieve for the design of 19.0 mm nominal maximum aggregate size mixtures is 97%, the production tolerance of ±5% is based on a control point of 100% passing the 25 mm sieve. Therefore, the allowable range for the percent passing the 25 mm sieve, for the production of 19.0 mm nominal maximum aggregate size mixtures, is 95 - 100%.***

While air voids govern the determination of the daily QAFs, the Producer shall maintain all volumetric properties within the tolerances listed above by adjusting the plant operations.

If a Production Status design consistently results in daily QAFs < 0.94 or consistently results in any volumetric property outside of the production tolerances (this may include Verification Status production) the Regional Materials Engineer may reject the design. The rejection will become effective after written notification is made and a "grace period" passes. The grace period will extend until the end of the day in which total production during the grace period reaches 2700 Mg. If adjustments are made to the design to improve the quality of the material produced during the grace period, the Producer may request reinstatement of the design. The Regional Materials Engineer is solely responsible for determining if a design should be reinstated. If a request for reinstatement is not made during the grace period, the rejection is final at the end of the grace period. Once the rejection is final, no additional changes are allowed and a complete redesign is required. If a design is rejected following the conclusion of paving operations for a construction season, the grace period will begin the first production day of the next year.

If a mixture cannot be properly placed and compacted, exhibits damage from the compaction operation, or exhibits poor performance (i.e., shoving, rutting, flushing, etc.), NYSDOT will immediately suspend production for that project according to §105 - Control of Work and §106- Control of Material. Paving operations will not resume until the cause of the problem has been identified and corrected to the satisfaction of the Regional Materials Engineer.

Note: ***When changes are made to the mixture proportions during production, the Producer must calculate the G_{sb}, fine aggregate angularity, flat-and-elongated particles, and coarse aggregate angularity of the new mixture, to assure that the new mixture meets all requirements.***

APPENDIX 1

VOLUMETRIC ANALYSIS OF RAW MATERIALS AND SUPERPAVE SPECIMENS

A. DEFINITION OF TERMS

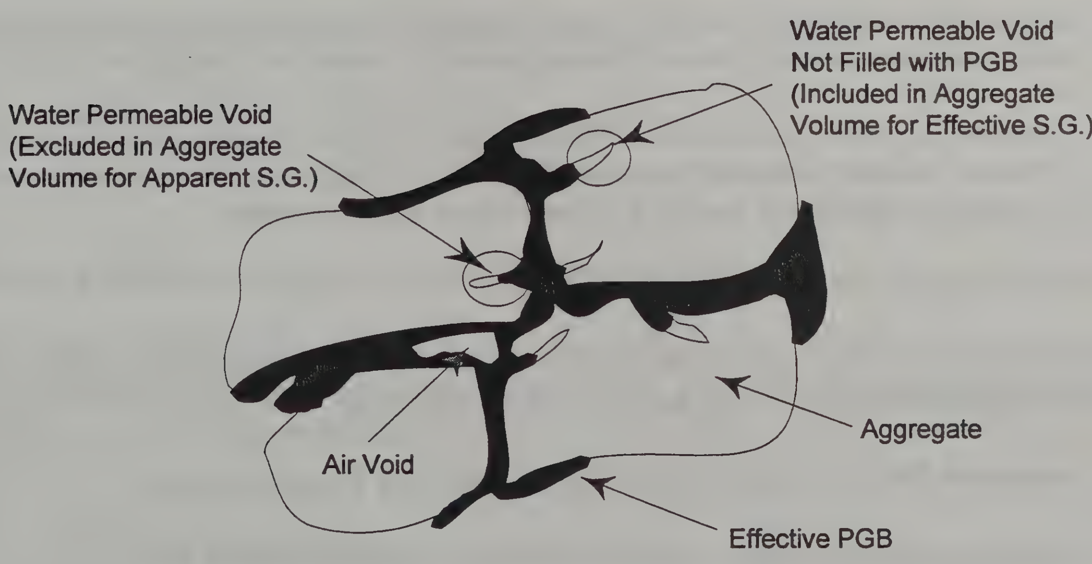
Mineral aggregates are porous and can absorb water and asphalt binder. The degree to which aggregates absorb water and binder varies from source to source. Also, the ratio of water to PGB absorption varies with each aggregate. Three methods of measuring aggregate specific gravity take these absorption variations into consideration (see Figure 1): bulk, apparent, and effective specific gravities. They are defined as follows:

Bulk Specific Gravity, G_{sb} - the ratio of the mass measured in air of a unit volume of permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass measured in air of equal density of an equal volume of water at a stated temperature.

Effective Specific Gravity, G_{se} - the ratio of the mass measured in air of a unit volume of a permeable material (excluding voids permeable to binder) at a stated temperature to the mass measured in air of equal density of an equal volume of water at a stated temperature.

Apparent Specific Gravity, G_{sa} - the ratio of the mass measured in air of a unit volume of an impermeable material at a stated temperature to the mass measured in air of equal density of an equal volume of water at a stated temperature.

Figure A-1 - PGB / Aggregate Matrix



***Note:* The volume of PGB absorbed by an aggregate is always less than the volume of water absorbed. Consequently, the value for the effective specific gravity of an aggregate should be numerically between its bulk and apparent specific gravities. When the effective specific gravity falls outside these limits, its value is assumed to be incorrect. The calculations, the maximum specific gravity of the total mixture (AASHTO T209), and the composition of the mixture in terms of aggregate and total PGB content should be rechecked for the source of error.**

The terms Air Voids (V_a), Effective Binder Content (P_{be}), Voids in the Mineral Aggregate (VMA), Voids in the Mineral Aggregate Filled with Binder (VFB) are used throughout this Materials Method, and are defined as follows:

Air Voids, V_a - the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture.

Effective Binder Content, P_{be} - the total PGB content of a paving mixture minus the portion of PGB that is absorbed into the aggregate particles.

Voids in the Mineral Aggregate, VMA - the volume of intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective binder content, expressed as a percent of the total volume of the sample.

VMA Filled With Binder, VFB - the ratio of volume of effective binder content, P_{be}, to the volume of voids in the mineral aggregate, VMA, expressed as a percent.

Dust to Effective Binder Ratio - The ratio of the percentage of mineral aggregate passing the 0.075 sieve to the percentage of the effective binder content, P_{be}.

Mixture Maximum Specific Gravity, G_{mm} - The ratio of a mass of a given volume of material to the mass of an equal volume of water. This represents the density of a sample with zero air voids.

Compacted Specimen Bulk Specific Gravity, G_{mb} - The ratio of a mass of a given volume of a compacted specimen (including impermeable air voids) to the mass of an equal volume of water. This represents the density of a sample at the compacted air void content.

B. Analysis Procedures

For all test procedures, use a scale readable to 0.1 g, and accurate to the requirements listed in **Table 7 - Scale Requirements**. Record all masses to the nearest 0.1 g.

1. Individual Material Constituent Specific Gravity Determination

Determine aggregate specific gravity according to AASHTO T84 and T85.

The aggregate specific gravities that are used to determine mixture volumetric properties during mixture verification and plant production monitoring will be based on the running average of the last six tests (or less) that were performed on each source. If no previous specific gravity testing has been performed, the previously untested aggregate used in the mixture design shall be tested and the resultant values used.

The apparent specific gravities of the PGB (AASHTO T228) and of the mineral filler (AASHTO T100) may be obtained from the supplier of these materials. PGB specific gravity at 25°C is needed for SHMA design, but the PGB specific gravity is generally given at 16°C. To convert this to the specific gravity at 25°C, apply a multiplication factor of 0.9941.

2. Composite Aggregate Bulk and Apparent Specific Gravity Determination

When the total aggregate consists of separate fractions of coarse and fine aggregate and mineral filler, the bulk and apparent specific gravities for the total aggregate are calculated as follows:

$$G_{sb} = G_{sa} = \left[\frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}} \right]$$

where:

G_{sb} = Bulk specific gravity for the total aggregate, reported to the nearest 0.001,
G_{sa} = Apparent specific gravity for the total aggregate,
P_n = % of individual aggregate components based on total mass of aggregate,
G_n = Bulk or apparent (whichever is applicable) specific gravities of aggregates.

Since the bulk specific gravity of mineral filler is difficult to determine, the apparent specific gravity is used instead. The error is usually negligible due to the small quantity of mineral filler in the hot mixture asphalt mixture.

Calculation using data from the Sample Mixture Design at 5.5% PGB:

$$G_{sb} = \left[\frac{9.45 + 28.35 + 28.35 + 28.35}{\frac{9.45}{2.553} + \frac{28.35}{2.671} + \frac{28.35}{2.671} + \frac{28.35}{2.671}} \right] = 2.659$$

3. Effective Specific Gravity of Aggregate Determination

The effective specific gravity, G_{se}, of the combined aggregates includes all void spaces in the aggregate particles except those that absorb PGB. This is based on the mixture maximum specific gravity, G_{mm} determined according to AASHTO T209. The G_{se} is calculated as follows:

$$G_{se} = \left[\frac{P_s}{\frac{P}{G_{mm}} - \frac{P_b}{G_b}} \right]$$

where:

G_{se}	=	effective specific gravity for the total aggregate,
P_s	=	aggregate, percent by total mass of mixture,
P	=	total loose mixture, percent by total mass of mixture = 100 percent,
G_{mm}	=	maximum specific gravity of hot mixture asphalt, AASHTO T209,
G_b	=	specific gravity of performance graded binder at 25°C.

Calculation using data from the Sample Mixture Design at 5.5% PGB:

$$G_{se} = \left[\frac{94.5}{\frac{100.0}{2.477} - \frac{5.5}{1.032}} \right] = 2.697$$

4. Aggregate Consensus Properties Determination

If any of the aggregate consensus quality requirements specified in the Contract Documents are not met for any of the aggregates used in the proposed mix design, the percentage of use for those aggregate will be limited in the total aggregate blend as determined by the law of partial fractions as detailed below.

$$EAQ = \frac{[AQ_r * PP(R)_r * PB_r] + AQ_1 * PP(R)_1 * PB_1 + \ldots + AQ_n * PP(R)_n * PB_n}{[PP(R)_r * PB_r] + PP(R)_1 * PB_1 + \ldots + PP(R)_n * PB_n}$$

where:

EAQ	=	Estimated Total Aggregate Consensus Property Quality, reported to the nearest 0.1,
Aq_n	=	Aggregate Consensus Property Quality (i.e., the percentage of Coarse Aggregate Angularity in a given stockpile),
$PP(R)_n$	=	Percentage Passing or Percentage Retained for the specified sieve size for each stockpile,
Pb_n	=	Blend Proportions for each stockpile,
Aq_r	=	Aggregate Consensus Property Quality of RAP aggregate (i.e., the percentage of Coarse Aggregate Angularity in the RAP stockpile),
$PP(R)_r$	=	Percentage Passing or Percentage Retained for the specific sieve size for the RAP stockpile,
Pb_r	=	Blend Proportion for the RAP stockpile (i.e., the percentage of aggregate in the total blend which is from the RAP stockpile).

If the estimated aggregate consensus property quality is below the requirement, reduce the percentage batched for the failing aggregate to bring it into conformance.

5. SUPERPAVE Specimen Bulk Specific Gravity Determination

Determine bulk specific gravity according to AASHTO T166.

The bulk specific gravity test may be performed as soon as the freshly compacted specimens have cooled to room temperature.

Calculate the bulk specific gravity to three decimal places. Specific gravity values that result in a range greater than 0.02 within the same PGB content shall be considered invalid and shall not be included in the data averaging. Additional SUPERPAVE gyratory compacted samples will be required if this situation occurs.

Calculate the bulk specific gravity of the specimen as follows:

$$G_{mb} = \frac{A}{(B - C)}$$

where:

G_{mb} = bulk specific gravity of compacted mixture, reported to the nearest 0.001,
A = mass of the dry specimen in air,
B = mass of the saturated surface dry specimen in air,
C = mass of specimen in water.

6. Mixture Maximum Specific Gravity Determination

Determine Mixture Maximum Specific Gravity according to AASHTO T209.

Test a minimum of two loose mixture specimens for each design aggregate trial blend or each PGB content used to determine the design PGB content. The sample size varies depending on the nominal maximum aggregate size of the mixture being tested and is detailed in the test procedure. Use a sample size of 3.000 kg for 37.5 mm nominal maximum size mixtures. The minimum pycnometer or flask size is 2000 ml (a 2000 g metal pycnometer is recommended). If the capacity of the pycnometer is not large enough to accommodate the required sample size the sample may be split into smaller samples (with a combined mass in excess of the required minimum sample size) and averaged (i.e., an average of four samples).

Maintain a constant minimum vacuum of 30 mm Hg in the pycnometer at all times. This level of vacuum is virtually impossible to maintain by any other means than a precision vacuum pump. The vacuum level should be maintained as close as possible to the required minimum of 30 mm Hg.

Note: NYSDOT recommends the use of a residual pressure manometer to monitor the vacuum achieved during this test.

Mixture maximum specific gravity results differing by more than 0.011 at the same PGB content shall be considered invalid and run again.

Calculate the specific gravity of the sample as follows:

$$G_{mm} = \frac{A}{A + D - E}$$

where:

G_{mm} = maximum specific gravity of SHMA, reported to the nearest 0.001,
A = mass of dry sample in air,
D = mass of flask filled with airless water at 25°C,
E = mass of flask filled with water and sample at 25°C,

***Note:* During the selection of the design PGB content for the selected aggregate structure the Producer may determine the mixture maximum specific gravity for each PGB content evaluated using the aggregate's effective specific gravity determined during the selection of the design aggregate structure phase of the mixture design. The mixture maximum specific gravity is calculated using the aggregate's effective specific gravity as follows:**

$$G_{mm} = \frac{100}{\dfrac{P_s}{G_{se}} + \dfrac{P_b}{G_b}}$$

where:

G_{mm} = mixture's maximum specific gravity
P_s = aggregate content, percent by total mass of mixture
P_b = PGB content, percent by total mass of mixture
G_{se} = effective specific gravity of aggregate
G_b = PGB specific gravity

7. Percentage Density (%G_{mm}) and Air Voids (V_a) Determination

Calculate the percentage density and air void content of the specimens using the SUPERPAVE gyratory compacted specimen average bulk specific gravity and the average mixture maximum specific gravity for each trial aggregate blend or PGB content used in the design PGB content phase of the mixture design, as follows:

$$\%\,G_{mm} = \frac{G_{mb}}{G_{mm}} \times 100$$

$$V_a = 100 - \%G_{mm}$$

where:

$\%G_{mm}$ = percentage compaction, % of the compacted specimens bulk density to the mixtures maximum density, reported to the nearest 0.01%,

G_{mb} = bulk specific gravity of SUPERPAVE gyratory compacted specimens,

G_{mm} = maximum specific gravity of SHMA mixture,

V_a = air voids in compacted mixture, % of total volume, reported to the nearest 0.01%.

8. Percent VMA Determination

The VMA is calculated on the basis of the bulk specific gravity of the aggregate (G_{sb}) and is expressed as a percentage of the bulk specific gravity of the compacted paving mixture (G_{mb}). Calculate the VMA is as follows:

$$VMA = 100 - \left[\frac{G_{mb} \ x \ P_s}{G_{sb}}\right]$$

where:

VMA = voids in mineral aggregate (% of bulk volume), reported to the nearest 0.1%,

G_{sb} = bulk specific gravity for the total aggregate,

G_{mb} = bulk specific bulk gravity of compacted mixture (AASHTO T166),

P_s = aggregate, percent by total mass of mixture.

Calculation using data from the Sample Mixture Design at 5.5% PGB:

$$VMA = 100 - \left[\frac{2.373 \ x \ 94.5}{2.659}\right] = 15.66$$

NOTE: ***During production it may be more expedient to use VMA based on the effective specific gravity of the aggregate, because the test method used to determine the bulk specific gravity of the aggregate is variable and time consuming. This alternative method may be used with the Regional Materials Engineer's approval.***

$$VMA_{eff} = 100 - \left|\frac{G_{mb} \ x \ P_s}{G_{se}}\right|$$

where:

VMA_{eff} = effective VMA; or VMA based on G_{se} instead of G_{sb}, reported to the nearest 01%

G_{mb} = bulk specific gravity of compacted mixture,

P_s = aggregate, percent by total mass of mixture,

G_{se} = effective specific gravity of total aggregate.

Because the effective specific gravity of the aggregate is smaller than the bulk specific gravity, the "Effective" VMA value will be higher. The Producer should determine an appropriate correction factor to compensate for this difference. The variability of values used in this calculation are less than the conventional approach.

$$VMA = VMA_{eff} \times C_f$$

where:

VMA = *voids in the mineral aggregate,*
VMA_{eff} = *effective VMA; or VMA based on G_{se} instead of G_{sb},*
C_f = *predetermined Correction Factor.*

9. Percent VMA Filled with Binder (VFB) Determination

The VFB is calculated on the basis of the Voids in the Mineral Aggregate (VMA) and is expresses as a percentage of the VMA that is filled with PGB. VFB is calculated as follows:

$$VFB = 100\left[\frac{VMA - V_a}{VMA}\right]$$

where:

VFB = % VMA filled with performance graded binder, reported to the nearest 0.1%,
VMA = Voids in the Mineral Aggregate,
V_a = Air Voids, percent of total volume.

Calculation using data from the Sample Mixture Design at 5.5% PGB:

$$VFB = 100\left[\frac{15.66 - 4.2}{15.66}\right] = 73.18$$

10. Effective Performance Graded Binder Content Determination

The effective PGB content of a paving mixture is the portion of the total PGB content that remains as a coating on the outside of the aggregate particles, and is the PGB content on which service performance of a hot mixture asphalt paving mixture depends. The effective PGB content is calculated as follows:

$$P_{be} = P_b - (G_b P_s)\left[\frac{G_{se} - G_{sb}}{G_{sb} G_{se}}\right]$$

where:

P_{be} = effective performance graded binder content, percent by total mass of mixture, reported t the nearest 0.1%
P_b = binder content, percent by total mass of mixture (for recycled mixtures use P_{tb}),

G_b	=	specific gravity of performance graded binder at 25°C,
P_s	=	aggregate, percent by total mass of mixture,
G_{se}	=	effective specific gravity of total aggregate,
G_{sb}	=	bulk specific gravity of total aggregate.

Calculation using data from the Sample Mixture Design at 5.5% PGB:

$$P_{be} = 5.0 - (1.0294 \times 94.5)\left[\frac{2.703 - 2.621}{2.621 \times 2.703}\right] = 3.9$$

11. Dust (Minus 0.075 mm Aggregate) to Effective PGB Content Ratio

The dust (minus 0.075 mm aggregate) to effective PGB content ratio is calculated as follows:

$$P_{0.075mm} / P_{be} = \frac{\% P_{0.075mm}}{P_{be}}$$

where:

$P_{0.075mm}/P_{be}$	=	Minus 0.075 mm aggregate to the effective PGB content ratio, reported to the nearest 0.1%,
$\%P_{0.075mm}$	=	percent of aggregate passing the 0.075 mm sieve, percent by total mass of aggregate,
P_{be}	=	effective performance graded binder content, percent by total mass of mixture.

Calculation using data from the Sample Mixture Design at 5.7% PGB:

$$P_{0.075mm} / P_{be} = \frac{2.8}{4.66} = 0.60$$

NOTES

APPENDIX 2

LABORATORY EQUIPMENT LIST

All manufacturers and models of equipment mentioned in this appendix are offered as examples which have been observed to conform consistently to the applicable AASHTO Standards. Calibrate each individual piece of equipment used in the preparation of a SHMA mixture design to the applicable AASHTO Standard ***before*** use. This is a suggested equipment list only.

General

1. Thermometers - of appropriate quality to meet the requirements of the specific tests
2. Sieve shaker
3. Fine aggregate splitter
4. Coarse aggregate splitter
5. Scales - meeting the requirements of AASHTO M231

Mixture Design and Analysis

1. SUPERPAVE gyratory compactor meeting the requirements of Item 18403.9995

Note: The Producer shall verify SUPERPAVE gyratory compactor's angle, pressure, and height measurements monthly, and maintain a log of these calibrations with the compactor.

2. Specimen mold assembly conforming to Item 18403.9995
3. Specimen extractor
4. Ovens - of appropriate quality to meet the requirements of the specific tests
5. Mixer - mechanical mixers are recommended
6. Bowls - stainless steel bowls are recommended
7. Steel spoons
8. Sample trays - suitable to run the short term aging test for both the gyratory specimen and the mixture maximum specific gravity specimen and meet the specified loading requirements

Mixture Maximum Specific Gravity Determination

1. Vacuum pump with gauge conforming to AASHTO T209
2. Pycnometers - for running test according to AASHTO T209, minimum capacity of 2000 ml, metal are recommended
3. Water tank - a watertight tank equipped with an overflow outlet for maintaining a constant water level, a heater and circulator are recommended
4. Residual pressure manometer - recommended but not required

Flat-and-Elongated Particles Determination

1. Suitable measuring equipment, a proportional caliper device is recommended

Fine Aggregate Angularity Determination

1. Cylindrical measure
2. Funnel
3. Funnel stand
4. Glass plate - for calibration

Sand Equivalent Content Determination

1. Graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly, and siphon assembly meeting the requirements of AASHTO T176
2. 85 ml tinned box
3. Wide mouth funnel - 100 mm in diameter at mouth
4. Shaker - either mechanical or manual

Specific Gravity and Absorption of Coarse Aggregate Determination

1. Wire basket conforming to AASHTO T85
2. Water tank - a watertight tank equipped with an overflow outlet for maintaining a constant water level, a heater and circulator are recommended

Specific Gravity and Absorption of Fine Aggregate Determination

1. Pycnometer conforming to AASHTO T84
2. Metal mold conforming to AASHTO T84
3. Tamper

Resistance of Compacted Bituminous Mixtures to Moisture Induced Damage Determination

1. Water bath - 60°C ± 1°C
2. Breaking head
3. Test press conforming to AASHTO T245
4. Suitable load measuring device conforming to AASHTO T245
5. Freezer

APPENDIX 3

COMPLETED MIXTURE DESIGN - SAMPLE

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE JMF Submittal Cover Sheet
and Forms Check List

REGION	1
PRODUCER	XYZ HMA Corporation
LOCATION	Dutchmenville, NY
JMF No.	

DESIGN ESAL LEVEL	NOMINAL MAX. SIZE
12.5 mm	< 3.0 Million

DRUM PLANT

- BR - 326 X
- Trial Blend Plot BR-267
- BR - 332 [trial blends] X
- BR - 319 [trial blends] X
- BR - 276 X
- BR - 332 [binder content] X
- BR - 319 [binder content] X
- BR - 293 X
- BR - 295 X
- BR-320 X
- BR-327 X
- JMF BR-254

DRUM PLANT (RAP)

- BR - 326 ______
- Trial Blend Plot ______
- BR - 332 [trial blends] ______
- BR - 319 [trial blends] ______
- BR - 277 ______
- BR - 332 [binder content] ______
- BR - 319 [binder content] ______
- BR - 294 ______
- BR - 295 ______
- BR-320 ______
- BR-327 ______
- JMF ______

BATCH PLANT

- BR - 326 [stockpiles] ______
- BR - 326 [hot bins] ______
- Trial Blend Plot ______
- BR - 332 [trial blends] ______
- BR - 319 [trial blends] ______
- BR - 276 ______
- BR - 332 [binder content] ______
- BR - 319 [binder content] ______
- BR - 293 ______
- BR - 295 ______
- BR-320 ______
- BR-327 ______
- JMF ______

BATCH PLANT (RAP)

- BR - 326 [stockpiles] ______
- BR - 326 [hot bins] ______
- Trial Blend Plot ______
- BR - 332 [trial blends] ______
- BR - 319 [trial blends] ______
- BR - 277 ______
- BR - 332 [binder content] ______
- BR - 319 [binder content] ______
- BR - 294 ______
- BR - 295 ______
- BR-320 ______
- BR-327 ______
- JMF ______

BR 326 (6/98)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Average Washed Gradation Summary

NUMBER OF SAMPLES AVERAGED: 10

REGION	1
PRODUCER	XYZ HMA Corporations
LOCATION	Dutchmenville, NY

AGGREGATE INFORMATION

Aggregates		Source Number	C. A. A.	F. A. A.	Flat & Elong.	Sand Equiv.
Coarse	No. 3 Stone					
	No. 2 Stone					
	No. 1 Stone					
	No. 1 Non - Carbonate Stone	1-4R	97/93		0.5	
	No. 1A Stone					
	No. 1A Non - Carbonate Stone	1-4R	98/94			
Fine	Manufactured	1-4R		48		65
	Natural Sand	1-8F		43		97
Mineral Filler						
RAP						
RAP Binder Content						

Remarks:

AVERAGE STOCKPILE / BIN BREAKDOWN

SIEVE SIZE (mm)	STOCKPILE / BIN NO. 1		STOCKPILE / BIN NO. 1A		STOCKPILE / BIN NO. Sand		STOCKPILE / BIN NO. Screenings		STOCKPILE / BIN NO.		STOCKPILE / BIN NO.		STOCKPILE / BIN NO.		STOCKPILE / BIN NO.		STOCKPILE / BIN NO.		MINERAL FILLER	
	retained	passing	retained	passing	retained	passing	retained	passing	retained	passing	retained	passing	retained	passing	retained	passing	retained	passing	retained	passing
50.0																				
37.5																				
25.0																				
19.0	0	100																		
12.5	4	96																		
9.5	39	57	0	100	0	100	0	100												
4.75	55	2	68	32	1	99	1	99												
2.36	1	1	30	2	26	73	23	76												
1.18			1	1	24	49	27	49												
0.600					20	29	16	33												
0.300					16	13	6	27												
0.150					7	6	9	18												
0.075					3	3	4	14												
PAN	1	0	1	1	3	0	14	0												
TOTAL	100		100		100		100													

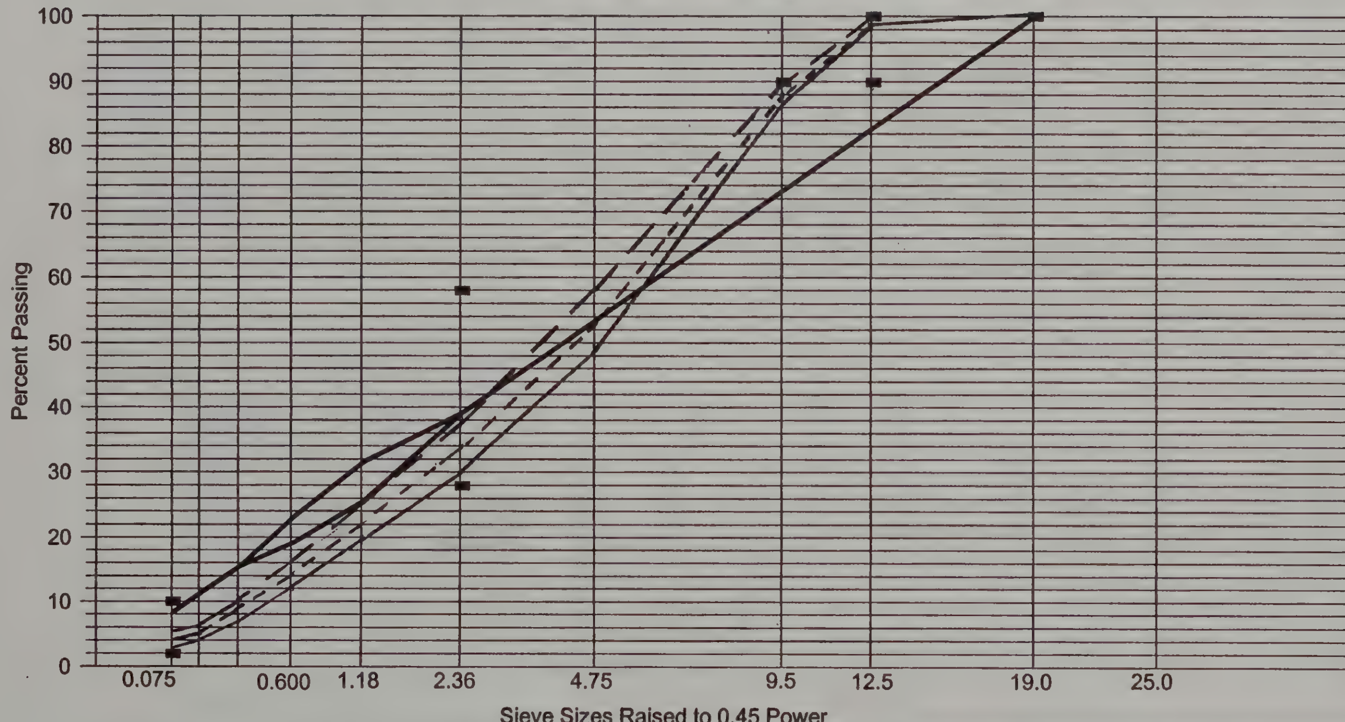
BR 267 (6/98)

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Design Aggregate Structure
Trial Blend Gradation Plot - 12.5 mm

REGION	1
PRODUCER	XYZHMA Corporation
LOCATION	Dutchmenville, NY

12.5 mm Nominal Maximum Size



Aggregates	Source Number	Blend 1 %	Blend 2 %	Blend 3 %
No. 3 Stone				
No. 2 Stone				
No. 1 Stone				
No. 1 Non-Carbonate Stone	1-4R	30	28	25
No. 1A Stone				
No. 1A Non-Carbonate Stone	1-4R	31	28	25
Manuf. Sand	1-4R	15	23	25
Natural Sand	1-8F	24	21	25
Mineral Filler				
RAP				

Consensus Properties	Blend 1	Blend 2	Blend 3
C. A. Angularity	98/94	98/94	98/94
F. A. Angularity	45	46	46
Flat & Elongated	0.025	0.025	0.025
Sand Equivalent	-	-	-

Sieve Size (mm)		0.075	0.150	0.300	0.600	1.18	2.36	4.75	9.5	12.5	19.0	25.0	37.5	50.0	% PGB	Binder Grade
% Passing	General Limits	2 - 10					28 - 58		< 90	90 - 100	100					
	Blend #1	2.8	4	7	12	20	30	49	87	99	100				5.7	PG - 58-34
	Blend #2	3.8	5	9	14	22	34	53	88	99	100				5.6	
	Blend #3	4.8	6	10	16	25	38	58	89	99	100				5.5	

Prepared By: Barney Gumble

Date: 3/12/99

Remarks:

BR 332 (3/99)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
<3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Design PGB Content
Mixture Maximum Specific Gravity Summary - AASHTO T209

REGION	1
PRODUCER	XYZ HMA Corporation
LOCATION	Dutchmenville, NY

☐ Trial Blends

☐ Design Binder Content Determination

G_{mm} = Maximum Specific Gravity of Hot Mix Asphalt
A = Mass of dry sample in air (grams)
D = Mass of pycnometer filled with water at 25°C (grams)
E = Mass of pycnometer filled with sample and water at 25°C(grams)

$$G_{mm} = \frac{A}{(A + D - E)}$$

Binder Content	5.7 %		5.6 %		5.5 %		%		%	
Test No.	1	2	1	2	1	2	1	2	1	2
A	1584.2	1593.4	1592.6	1582.4	1581.1	1591.5				
D	7653.7	7649.8	7653.7	7649.8	7653.7	7649.8				
E	8597.8	8599.4	8600.5	8590.5	8600.6	8602.9				
G_{mm}	2.459	2.464	2.456	2.448	2.474	2.484				
Avg. G_{mm}	2.462		2.452		2.479					

Tested by: Barney Gumble

Date: 3/12/99

BR 319 (3/99)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Design PGB Content
Compacted Specimen Density Worksheet

[X] Trial Blends
[ ] Design Binder Content Determination

REGION: 1
PRODUCER: XYZ HMZ Corporation
LOCATION: Dutchmenville, NY

							@ N - design			@ N - initial			@ N - maximum		
Specimen	PGB Content (%)	Specimen Mass In Air (g)	Specimen Mass S. S. D. (g)	Specimen Mass In Water (g)	Volume (mL)	Maximum Specific Gravity Gmm	Bulk Specific Gravity Gmb	% Gmm	Specimen Height (mm)	Specimen Height (mm)	Bulk Specific Gravity Gmb	% Gmm	Bulk Specific Gravity Gmb	% Gmm	Specimen Height (mm)
		a	b	c	d	c	f	g	h	i	k	m	n	o	
					b - c		a / d	100 (f / e)			f (h / i)	100 (k / e)	a / d	100 (n / e)	
A	5.7	4788.1	4793.0	2765.0	2023.1		2.367	96.1	114.1	128.8	2.097	85.2			
B	5.7	4798.9	4803.1	2777.5	2021.4		2.374	96.4	113.8	128.5	2.102	85.4			
AVG.						2.462	2.371	96.3			2.100	85.3			
A	5.6	4737.3	4738.9	2758.4	1980.5		2.392	97.5	114.2	129.0	2.117	86.3			
B	5.6	4759.3	4760.5	2770.8	1989.7		2.392	97.5	114.9	130.0	2.114	86.2			
AVG.						2.452	2.392	97.5			2.116	86.3			
A	5.5	4766.5	4767.3	2792.8	1974.5		2.414	97.4	113.4	127.4	2.149	86.7			
B	5.5	4751.9	4752.5	2782.4	1970.1		2.412	97.3	113.2	127.4	2.143	86.4			
AVG.						2.479	2.413	97.3			2.146	86.6			
A															
B															
AVG.															
A															
B															
AVG.															

* Note: N-final number of gyrations will not be the same as N-maximum when back calculating for use as a lower traffic volume design.

PREPARED BY: Barney Gumble

DATE: 3/12/99

BR 276 (3/99)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Design Aggregate Structure Trial Blend
Compacted Specimen Volumetric Property Summary

REGION	1
PRODUCER	ZYZHMA Corporation
LOCATION	Dutchmenville, NY

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

COMPOSITION OF SUPERPAVE TRIAL BLENDS (Analysis by mass of total mixture)

Constituent Material		NYS DOT Source Number	Specific Gravity, G		Mixture Composition % by Mass of Total Mixture, P				
			Apparent	Bulk		Reg. Ver.	Trial Blend Number 1	2	3
C.A.	No. 3 Stone								
	No. 2 Stone				P1				
	No. 1 Stone				P2				
	No. 1 Non - Carbonate Stone	1-4R	2.715	2.607	P3		28.29	26.43	23.63
	No. 1A Stone				P4				
	No. 1A Non-Carbonate Stone	1-4R	2.715	2.607	P5		29.23	26.43	23.62
F.A.	Manufactured	1-4R	2.718	2.675	P6		14.15	21.72	23.63
	Natural	1-8F	2.711	2.597	P7		22.63	19.82	23.62
Mineral Filler					P8				
TOTAL AGGREGATE					Ps		94.3	94.4	94.5
PGB CONTENT@ 25 C				1.022	Pb(ini)		5.7	5.6	5.5

			1	2	3
Gmm	Maximum Specific Gravity of Mixture (AASHTO T209)		2.462	2.452	2.479
Gmb@Nini	Bulk Specific Gravity of Compacted Mixture @ Nini Gyrations		2.100	2.116	2.146
%Gmm@Nini	%Gmm@Nini = (Gmb@Nini / Gmm) x 100		85.3	86.3	86.6
Gmb@Ndes	Bulk Specific Gravity of Compacted Mixture @Ndes Gyrations		2.371	2.392	2.413
%Gmm@Ndes	%Gmm@Ndes = (Gmb@Ndes / Gmm) x 100		96.3	97.5	97.3
Va@Ndes	Va(@Ndes) = [(Gmm - Gmb@Ndes) / Gmm] x 100		3.7	2.5	2.7
Gsb	Bulk Specific Gravity of Total Aggregate		2.615	2.620	2.621
Gsa	Apparent Specific Gravity of Total Aggregate		2.714	2.715	2.715
Gse	Effective Specific Gravity of Total Aggregate Gse = Ps / [(100 / Gmm) - (Pb / Gb)]		2.691	2.674	2.703
VMA	VMA = 100 - (Gmb@Ndes x Ps / Gsb)		14.5	13.8	13.0
Pb(est)	Pb(est) = Pb(ini) - {0.4 x [4 - Va@Ndes)]}		5.6	5.0	5.0
VMA(est)	VMA(est) = VMA + [C x (4 - Va@Ndes)] w/ C=0.1 if Va@Ndes < 4.0; or if > 4.0 then C=0.2		14.5	14.0	13.1
VFB(est)	VFB(est) = [(VMA(est) - 4) / VMA(est)] x 100		72.4	71.4	69.5
Pbe	Effective PGB Content, Pbe = Pb(est) - {(Ps x Gb) x [(Gse - Gsb) / (Gse x Gsb)]}		4.6	4.0	3.9
[F/Pbe](est)	Fines to Pbe Ratio = (% passing 0.075 mm sieve) / Pbe		0.61	0.88	1.1

Blend Selected and Why? Blend No. 1, because it meets all criteria.

* EQUATIONS FROM NYSDOT MATERIALS METHOD 5.16

PREPARED BY: Barney Gumble DATE: 3/12/99

BR 332 (3/99)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
<3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Design PGB Content
Mixture Maximum Specific Gravity Summary - AASHTO T209

REGION	1
PRODUCER	XYZ HMA Corporation
LOCATION	Dutchmenville, NY

☐ Trial Blends
☒ Design Binder Content Determination

G_{mm} = Maximum Specific Gravity of Hot Mix Asphalt
A = Mass of dry sample in air (grams)
D = Mass of pycnometer filled with water at 25°C (grams)
E = Mass of pycnometer filled with sample and water at 25°C(grams)

$$G_{mm} = \frac{A}{(A + D - E)}$$

Binder Content	5.2 %		5.7 %		6.2 %		6.7 %		5.6 %	
Test No.	1	2	1	2	1	2	1	2	1	2
A	1583.6	1582.2	1584.6	1593.8	1580.0	1587.3	1584.3	1584.6	1585.3	1584.8
D	7653.7	7649.8	7653.7	7649.8	7653.7	7649.8	7653.7	7649.8	7652.8	7654.1
E	8601.3	8596.6	8597.8	8599.4	8591.8	8592.4	8590.0	8586.3	8592.6	8594.7
G_{mm}	2.480	2.474	2.549	2.464	2.450	2.448	2.435	2.431	2.456	2.460
Avg. G_{mm}	2.477		2.462		2.449		2.433		2.458	

Tested by: Barney Gumble

Date: 3/12/99

BR 319 (3/99)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Design PGB Content
Compacted Specimen Density Worksheet

☐ Trial Blends
☒ Design Binder Content Determination

REGION	1
PRODUCER	XYZ HMZ Corporation
LOCATION	Dutchmenville, NY

		Specimen Mass					@ N - design			@ N - initial			@ N - maximum		
Specimen	PGB Content (%)	In Air (g)	S. S. D. (g)	In Water (g)	Volume (mL)	Maximum Specific Gravity Gmm	Bulk Specific Gravity Gmb	% Gmm	Specimen Height (mm)	Specimen Height (mm)	Bulk Specific Gravity Gmb	% Gmm	Bulk Specific Gravity Gmb	% Gmm	Specimen Height (mm)
		a	b	c	d	c	f	g	h	i	k	m	n	o	
					b - c		a / d	100 (f / e)			f (h / i)	100 (k / e)	a / d	100 (n / e)	
A	5.2	4674.4	4681.2	2694.6	1986.6		2.353	96.6	115.2	129.7	2.090	84.4			
B	5.2	4675.6	4680.5	2701.0	1979.5		2.362	97.0	114.3	128.9	2.095	84.6			
AVG.						2.477	2.358	96.8			2.093	84.5			
A	5.7	4673.9	4677.6	2698.0	1979.6		2.361	97.8	114.1	128.8	2.097	85.2			
B	5.7	4669.7	4678.0	2711.0	1967.0		2.374	98.0	113.8	128.5	2.102	85.4			
AVG.						2.462	2.368	97.9			2.100	85.3			
A	6.2	4677.0	4681.5	2718.6	1962.9		2.385	98.9	113.5	128.4	2.108	86.1			
B	6.2	4671.2	4678.3	2717.6	1960.7		2.386	99.0	113.1	128.0	2.109	86.1			
AVG.						2.449	2.386	99.0			2.109	86.1			
A	6.7	4679.4	4682.0	2729.0	1953.0		2.396	99.6	112.0	126.9	2.115	86.9			
B	6.7	4675.7	4680.1	2725.4	1954.7		2.392	99.6	112.4	127.2	2.113	86.8			
AVG.						2.443	2.394	99.6			2.114	86.9			
A	5.6	4675.6	4679.1	2776.9	1902.2								2.401	97.7	112.0
B	5.6	4678.3	4682.1	2778.8	1903.3								2.406	97.9	111.2
AVG.						2.458							2.404	97.8	

* Note: N-final number of gyrations will not be the same as N-maximum when back calculating for use as a lower traffic volume design.

PREPARED BY: Barney Gumble

DATE: 3/12/99

BR 293 (2/99)

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU

SUPERPAVE Design PGB Content
Compacted Specimen Volumetric Property Summary

REGION	1
PRODUCER	XYZ HMA Corporation
LOCATION	Dutchmenville, NY

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

COMPOSITION OF SUPERPAVE MIXTURES (Analysis by mass of total mixture)

	Constituent Material	NYS DOT Source Number	Specific Gravity, G Apparent	Specific Gravity, G Bulk	Mixture Composition % by Mass of Total Mixture, P	Reg. Ver.	Mix Sample 1	2	3	4	Design
C.A.	No. 3 Stone										
	No. 2 Stone				P1						
	No. 1 Stone				P2						
	No. 1 Non - Carbonate Stone	1-4R	2.715		P3		28.44	28.29	28.14	27.99	28.32
	No. 1A Stone				P4						
	No. 1A Non- Carbonate Stone	1-4R	2.715		P5		29.39	29.23	29.08	28.92	29.26
F.A.	Manufactured	1-4R	2.718		P6		14.22	14.15	14.07	14	14.16
	Natural	1-8F	2.711		P7		22.75	22.63	22.51	22.39	22.66
Mineral Filler					P8						
TOTAL AGGREGATE					Ps		94.8	94.3	93.8	93.3	94.4
BINDER CONTENT @ 25 C			1.022		Pb		5.2	5.7	6.2	6.7	5.6
Gmm	Maximum Specific Gravity of Mixture (AASHTO T209)						2.477	2.462	2.449	2.433	2.458
Gmb@Nmax	Bulk Specific Gravity of Compacted Mixture @ Nmax Gyrations (AASHTO T166)										2.404
%Gmm@Nmax	% Gmm @Nmax = (Gmb@Nmax / Gmm) x 100										97.8
Gmb@Nini	Bulk Specific Gravity of Compacted Mixture @ Nini Gyrations						2.093	2.1	2.109	2.114	
%Gmm@Nini	%Gmm@Nini = (Gmb@Nini / Gmm) x 100						84.5	85.3	86.1	86.9	
Gmb@Ndes	Bulk Specific Gravity of Compacted Mixture @Ndes Gyrations						2.358	2.368	2.386	2.394	
%Gmm@Ndes	%Gmm@Ndes = (Gmb@Ndes / Gmm) x 100						95.2	96.2	97.4	98.4	
Va@Ndes	Va(@Ndes) = [(Gmm - Gmb@Ndes) / Gmm] x 100						4.8	3.8	2.6	1.6	
Gsb	Bulk Specific Gravity of Total Aggregate						2.615	2.615	2.615	2.615	
Gsa	Apparent Specific Gravity of Total Aggregate						2.714	2.714	2.714	2.714	
Gse	Effective Specific Gravity of Total Aggregate Gse = Ps / [(100 / Gmm) - (Pb / Gb)]						2.686	2.691	2.698	2.701	
VMA	VMA = 100 - (Gmb@Ndes x Ps / Gsb)						14.5	14.6	14.4	14.6	
VFB	VFB = [(VMA - Va) / VMA] x 100						66.9	74	81.9	89	
Pbe	Effective PGB Content, Pbe = Pb - {(Ps x Gb) x [(Gse - Gsb) / (Gse x Gsb)]}						4.22	4.66	5.07	5.54	
F/Pbe	Fines to Pbe Ratio = (%passing 0.075 mm sieve) / Pbe						0.66	0.6	0.55	0.51	

Remarks:

* EQUATIONS FROM NYSDOT MATERIALS METHOD 5.16

PREPARED BY: Barney Gumble

DATE: 3/12/99

NOMINAL MAX. SIZE
12.5 mm

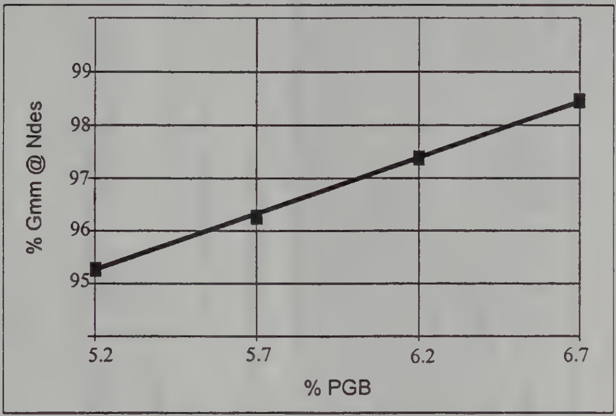
DESIGN ESAL LEVEL
< 3.0 Million

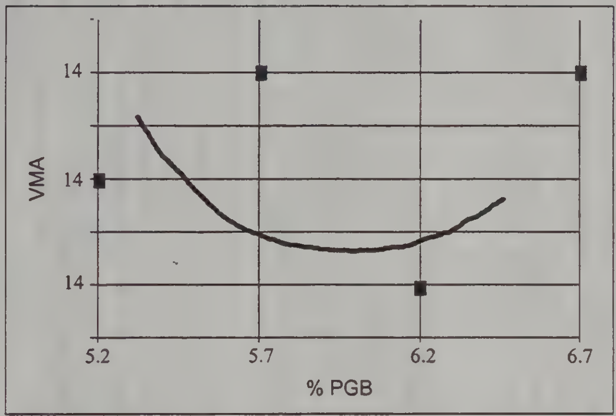
NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Volumetric Property Curves

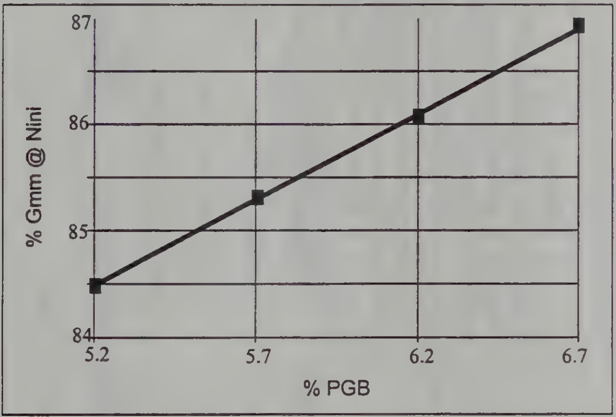
REGION
1

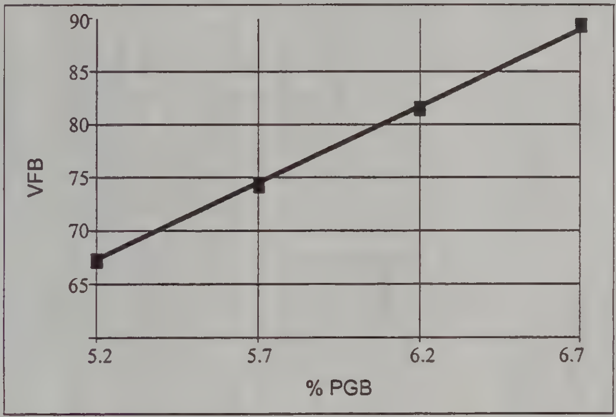
PRODUCER
XYZ HMA Corporations

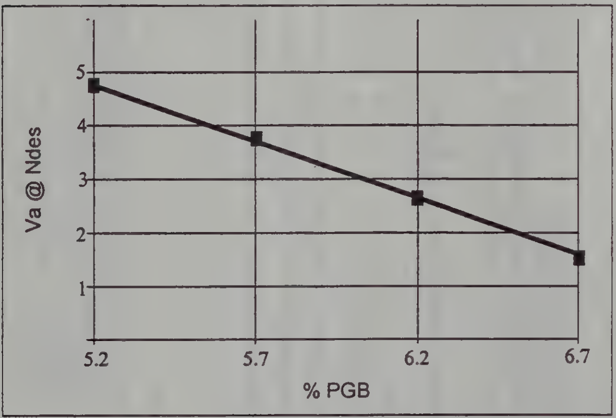
LOCATION
Dutchmenville, NY

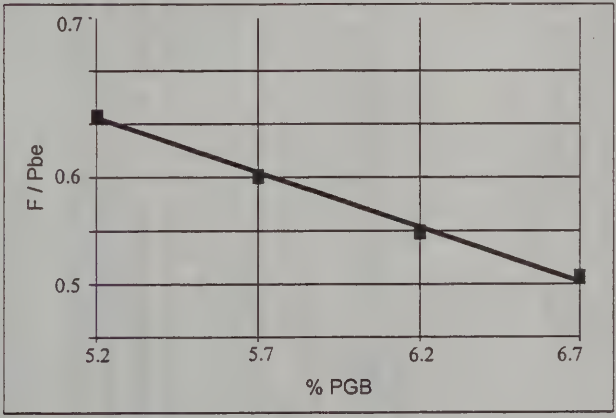












VALUES AT DESIGN PGB CONTENT

Property	% Gmm @ Nmax	% Gmm @ Nini	@ Ndes Va (%)	@ Ndes VMA (%)	@ Ndes VFB (%)	@ Ndes F / Pbe
Specs.	< 98%	< 89.5	4.00%	> 14.0	65-78	0.6-1.2
Actual	97.8	85.1	4.00 %	14.5	73	0.62

DESIGN PGB CONTENT

5.60%

SUBMITTED BY: Barney Gumble

DATE: 3/12/99

BR 320 (3/99)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Performance Graded Binder
Temperature Viscosity Data

REGION	1
PRODUCER	XYZ HMA Corporation
LOCATION	Dutchmenville, NY

Variables:

$\mu_{1,2}$ = Viscosity in centipoise
G_b = Asphalt Bulk Specific Gravity @ 25 °C, AASHTO T 228
G_b = ________
U = $Log_{10}(Log_{10}(\mu))$
m = slope of the line
b = Y axis intercept (Log_{10} - $Log_{10}(\mu)$)

Given Variables:

μ_{HM} = Viscosity in centistokes, High Mixing = 150 cSt
μ_{LM} = Viscosity in centistokes, Low Mixing = 190 cSt
μ_{HC} = Viscosity in centistokes, High Compaction = 250 cSt
μ_{LC} = Viscosity in centistokes, Low Compaction = 310 cSt

U_{HM} = $Log_{10}(Log_{10}(\mu))$, High Mixing = 0.3377
U_{LM} = $Log_{10}(Log_{10}(\mu))$, Low Mixing = 0.3577
U_{HC} = $Log_{10}(Log_{10}(\mu))$, High Compaction = 0.3798
U_{LC} = $Log_{10}(Log_{10}(\mu))$, Low Compaction = 0.3964

T_1 = Test Temperature One, in Celsius = 135 °C
T_2 = Test Temperature Two, in Celsius = 165 °C
T_{K1} = Test Temperature One, in kelvin, 135°+273° = 408 °K
T_{K1} = Test Temperature Two, in kelvin, 165°+273° = 438 °K

Conversion Factors, for converting centipoise to centistokes:

$CF_{135°C}$ = Viscosity Reading at 135 °C = 0.9325
$CF_{165°C}$ = Viscosity Reading at 165 °C = 0.9145

Remarks:

CALCULATIONS

Variable	Calculation	Result
μ_1 cP	Rotational Viscometer Reading at 135 °C, in centipoise	364 cP
μ_1 cSt	μ_1 cP / (0.9325 x G_b), Conversion to centistokes	379 cSt
U_1	$Log_{10}(Log_{10}(\mu_1$ cSt))	0.4114
t_1	$Log_{10}(T_{K1})$	2.611
μ_2 cP	Rotational Viscometer Reading at 165 °C, in centipoise	100 cP
μ_2 cSt	μ_2 cP / (0.9145 x G_b), Conversion to centistokes	106 cSt
U_2	$Log_{10}(Log_{10}(\mu_2$ cSt))	0.3065
t_2	$Log_{10}(T_{K2})$	2.637
m	$(U_2 - U_1) / (t_2 - t_1)$	-4.035
b	$U_1 - m \times t_1$	10.9468
T_{HM}	$10^{(0.3377 - b)/m}$ - 273, High Mixing Temperature	153 °C
T_{LM}	$10^{(0.3577 - b)/m}$ - 273, Low Mixing Temperature	148 °C
T_{HC}	$10^{(0.3798 - b)/m}$ - 273, High Compaction Temperature	143 °C
T_{LC}	$10^{(0.3964 - b)/m}$ - 273, Low Compaction Temperature	139 °C

RECOMMENDED TEMPERATURES WHEN USING MODIFIED BINDERS:

High Mixing Temp. = ______°C Low Mixing Temp. = ______°C
High Compaction Temp. = ______°C Low Compaction Temp. = ______°C
Initial If Using Recommend Temperatures: ________

SIGNATURE: Barney Gumble

BR 327 (6/98)

NOMINAL MAX. SIZE
12.5 mm

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Batch Masses for Mixture Verification

REGION	1
PRODUCER	XYZ HMA Corporation
LOCATION	Dutchmenville, NY

COMBINED SUPERPAVE (GYRATORY SAMPLE) GRADATION AT THE % PGB INDICATED (% total binder for RAP mixtures)

% PGB	Aggregate Componant	% Batch	Batch Mass (g)	Mass Retained (g) 50.0 mm	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	Pan	Total Retained
5.6	1	30	1359.4				0	54.4	530.1	747.7	13.6	13.6	1359.4
	1A	31	1404.6				0	0	0	955.1	421.4		1404.6
	Sand	24	1087.5				0	0	0	10.9	282.8		1087.5
	Screenings	15	679.7				0	0	0	6.8	156.3		679.7
	Mineral Filler												
	TOTAL	100	4531.2										

4800 g (specimen mass) X 5.6 % (PGB content) = 268.8 g (PGB mass)   4800 g (specimen mass) - 268.8 g (PGB mass) = 4531.2 g (Agg. mass)

COMBINED SUPERPAVE (MAXIMUM SPECIFIC GRAVITY SAMPLE) GRADATION AT THE % PGB INDICATED (% total binder for RAP mixtures)

% PGB	Aggregate Componant	% Batch	Batch Mass (g)	Mass Retained (g) 50.0 mm	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm	2.36 mm	Pan	Total Retained
5.6	1	30	453.1				0	18.1	176.7	249.3	4.5	4.5	453.1
	1A	31	468.2				0	0	0	318.3	140.5	9.4	468.1
	Sand	24	362.5				0	0	0	3.6	94.3	264.6	365.2
	Screenings	15	226.6				0	0	0	2.3	52.1	172	226.6
	Mineral Filler												
	TOTAL	100	1510.4										

1600 g (specimen mass) X 5.6 % (PGB content) = 89.6 g (PGB mass)   1600 g (specimen mass) - 89.6 g (PGB mass) = 1510.4 g (Agg. mass)

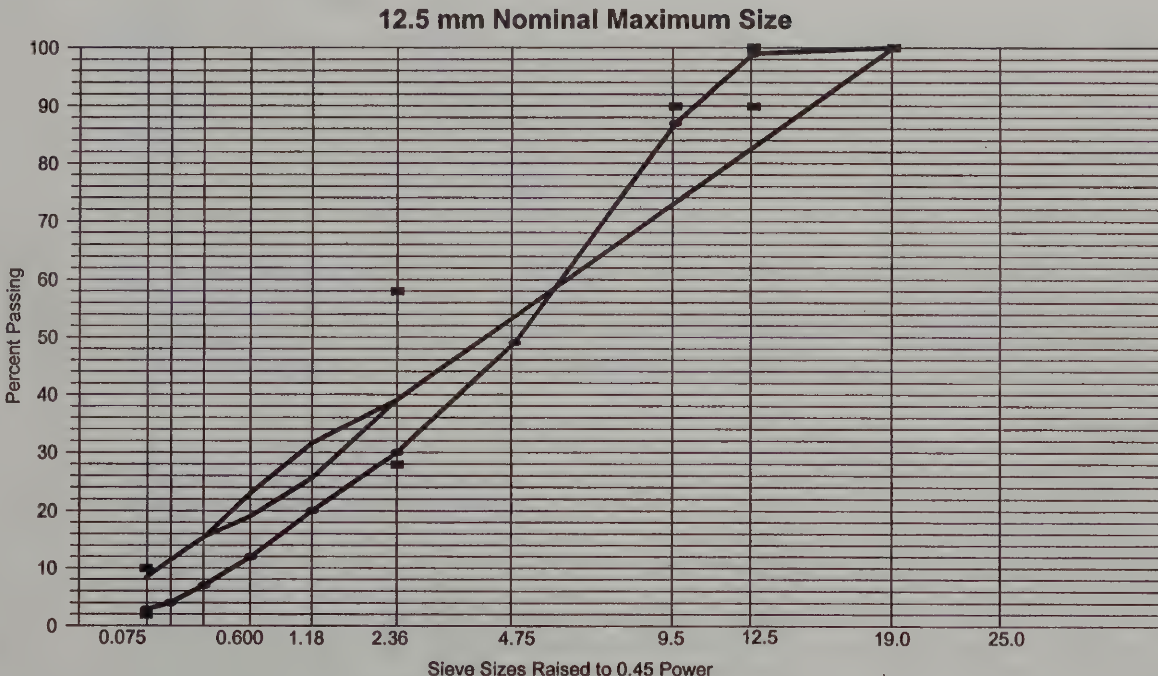
PREPARED BY: Barney Gumble   DATE: 3/12/99

BR 254 (3/99)

DESIGN ESAL LEVEL
< 3.0 Million

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE Job Mix Formula
12.5 mm Nominal Maximum Size

REGION	JMF No.
1	
PRODUCER	
XYZ HMA Corporation	
LOCATION	
Dutchmenville, NY	



	Aggregates	Source Number	Blend %	
Coarse	No. 1 Stone			1 Fric. Blend
	No. 1 Non-Carbonate Stone	1-4R	30	100%
	No. 1A Stone			1A Fric. Blend
	No. 1A Non-Carbonate Stone	1-4R	31	100%
Fine	Manufactured	1-4R	15	Sand Blend
	Natural Sand	1-8F	24	40/60
	Mineral Filler			
	RAP			

	Aggregates	Blend Limits to Maintain C.A.P.'s		
		C. A. A.	F. A. A.	Flat / El.
Coarse	No. 1 Stone			
	No. 1 Non-Carbonate Stone	N/A		N/A
	No. 1A Stone			
	No. 1A Non-Carbonate Stone	N/A		N/A
Fine	Manufactured		N/A	
	Natural Sand		N/A	
	RAP			

Sieve Size (mm)		0.075	0.150	0.300	0.600	1.18	2.36	4.75	9.5	12.5	19.0	25.0	% PGB	Binder Grade
% Passing	General Limits	**2 - 10**					**28 - 58**		**< 90**	**90 - 100**	**100**			
	JMF Range	0.8 - 4.8	1 - 7	3 - 10	9 - 10	16 - 24	26 - 34	45 - 53	82 - 92	94 - 100	95 - 100		5.6	PG - 58-34
	Target Value	2.8	4	7	12	20	30	49	87	99	100		5.6	

Submitted for Review by: Barney Gumble Date: 3/12/99

Accepted for Verification / Production by: Eric Cartman Date: 3/12/99

Revised
2/97
2/98
9/98
3/99

APPENDIX 4

JMF SUBMITTAL COVER SHEET

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION
MATERIALS BUREAU
SUPERPAVE JMF Submittal Cover Sheet and Forms Check List

REGION
PRODUCER
LOCATION
JMF No.

DESIGN ESAL LEVEL	NOMINAL MAX. SIZE

DRUM PLANT	DRUM PLANT (RAP)	BATCH PLANT	BATCH PLANT (RAP)
BR - 326 ______	BR - 326 ______	BR - 326 [stockpiles] ______	BR - 326 [stockpiles] ______
Trial Blend Plot ______	Trial Blend Plot ______	BR - 326 [hot bins] ______	BR - 326 [hot bins] ______
BR - 332 [trial blends] ______	BR - 332 [trial blends] ______	Trial Blend Plot ______	Trial Blend Plot ______
BR - 319 [trial blends] ______	BR - 319 [trial blends] ______	BR - 332 [trial blends] ______	BR - 332 [trial blends] ______
BR - 276 ______	BR - 276 ______	BR - 319 [trial blends] ______	BR - 319 [trial blends] ______
BR - 332 [binder content] ______	BR - 332 [binder content] ______	BR - 276 ______	BR - 277 ______
BR - 319 [binder content] ______	BR - 319 [binder content] ______	BR - 332 [binder content] ______	BR - 332 [binder content] ______
BR - 293 ______	BR - 294 ______	BR - 319 [binder content] ______	BR - 319 [binder content] ______
BR - 295 ______	BR - 295 ______	BR - 293 ______	BR - 294 ______
BR-320 ______	BR-320 ______	BR - 295 ______	BR - 295 ______
BR-327 ______	BR-327 ______	BR-320 ______	BR-320 ______
JMF ______	JMF ______	BR-327 ______	BR-327 ______
		JMF ______	JMF ______

APPENDIX 5

SUPERPAVE DEFINITION OF TERMS AND ABBREVIATIONS

AQ_n	=	aggregate consensus property quality
AQ_r	=	aggregate consensus property quality of the RAP aggregate
EAQ	=	estimated total aggregate consensus property quality
ESAL	=	equivalent single axel load
JMF	=	job mix formula
G_b	=	specific gravity of performance graded binder, at 25°C
G_{mb}	=	bulk specific gravity of compacted mixture
G_{mm}	=	maximum specific gravity of bituminous mixture
G_n	=	bulk or apparent (whichever is applicable) specific gravities of aggregates
G_{sa}	=	apparent specific gravity for the total aggregate
G_{sb}	=	bulk specific gravity for the total aggregate
G_{se}	=	effective specific gravity for the total aggregate
$N_{initial}$	=	initial number of gyrations, determined by traffic loading
N_{design}	=	design number of gyrations, determined by traffic loading
$N_{maximum}$	=	maximum number of gyrations, determined by traffic loading
P	=	% total SUPERPAVE HMA mixture by mass = 100%
P_b	=	performance graded binder, percent by total mass of mixture
P_{be}	=	effective performance graded binder content, percent by total mass of
P_n	=	% of individual aggregate components, based on total mass of aggregate mixture
P_r	=	RAP blend proportion, % by total mass of mix
P_{rb}	=	RAP binder content, % by total mass of RAP which is binder
P_s	=	aggregate, percent by total mass of mixture
P_{tb}	=	total binder content, percent by total mass of mixture (RAP mixtures only)
$P_{0.075\ mm}/P_{be}$	=	minus 0.075 mm aggregate to the effective PGB content ratio
PB_n	=	blend proportions for each stockpile
PB_r	=	blend proportion for aggregate from RAP stockpile
PGB	=	performance graded binder

$PGB_{estimated}$	=	Estimated Performance Graded Binder content
PGBM	=	total performance graded binder batch mass
$PP(R)_n$	=	percent passing or retained for the specified sieve size (R) for each stockpile (N)
$PP(R)_r$	=	percent passing or retained for the specified sieve size (R) for the RAP stockpile (r)
QAF	=	quality adjustment factor
RAP	=	reclaimed asphalt pavement
SHMA	=	SUPERPAVE hot mix asphalt
SHRP	=	Strategic Highway Research Program
TABM	=	total aggregate batch mass
TSM	=	total specimen mass
TMA	=	total mass of aggregate batched
TSR	=	tensile stress ratio
V_a	=	air voids in compacted mixture, % of total volume
VFB	=	% of VMA filled with effective performance graded binder
VMA	=	voids the in mineral aggregate (% of bulk volume)
VMA_{eff}	=	effective VMA; VMA determined using G_{se}

Superpave Mix Coding Description

Nominal Maximum Aggregate Size	Friction Aggregate Requirements	Design ESAL Level	Consensus Properties	Binder Type
37 = 37.5 mm	F1 = Downstate High Volume	5 = >30 million	Y = <100 mm	A = PG 58 -34
25 = 25. 0 mm	F2 = Upstate High Volume	4 = <30 million	N = >100 mm	B = PG 58 -28
19 = 19.0 mm	F3 = Low Volume	3 = <10 million		C = PG 64 -22
12 = 12.5 mm	F9 = Friction not Required	2 = <3 million		D = PG 64 -28
09 = 9.5 mm		1 = <0.3 million		E = PG 70 -22
				G = PG 76 -22